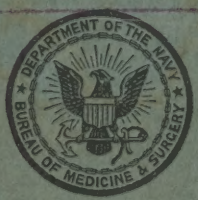
TREATMENT OF CASUALTIES

FROM

CHEMICAL WARFARE AGENTS



NAVMED 220 (Revised July 1945)

A MANUAL
FOR THE INFORMATION AND GUIDANCE
OF MEDICAL OFFICERS
UNITED STATES NAVY

[redacted]

MANUAL ON

TREATMENT OF CASUALTIES

FROM

CHEMICAL WARFARE AGENTS

(This Manual supersedes NAVMED 220 of 20 July 1944)

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PREFACE

This revised Manual on the Treatment of Casualties from Chemical Warfare Agents is published for the information and guidance of medical officers.

Its purpose is to make available in concise form the most recent and generally accepted data concerning self-aid, first aid, and definitive treatment of casualties from Chemical Warfare Agents. Certain additional topics with respect to gas defense falling under the cognizance of the medical officer, have also been included.

This material is largely based upon the latest revision of Technical Manual TM8–285, Treatment of Casualties from Chemical Agents, War Department. Representatives of the Medical Corps of the Navy and of the Committee on the Treatment of Gas Casualties of the National Research Council collaborated with representatives of the Medical Division of the Chemical Warfare Service, War Department, in the preparation of this revision. Acknowledgment is made herewith to the Surgeon General, United States Army, for authority to duplicate certain chapters.

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Surgeon General, United States Navy.

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GENERAL

1. INTRODUCTION

Chemical warfare agents are used to produce casualties, to make areas both ashore and afloat impassable or untenable, to render food, water and material unusuable, to provide concealment, and to start fires.

The scope of chemical warfare is broad. It aims at groups rather than individuals. Gas may penetrate turrets, compartments, emplacements, dugouts, and trenches. Projected from the airplane, chemical agents may produce casualties and contamination in topside battle stations, or within ships even though far out to sea, as well as on shore stations, beaches, or far back into rear areas.

In contemplating casualties due to gas attack, cognizance must be given to specific problems pertaining to naval operations in contrast to shore operations. Especially should it be stressed that contaminated areas on land may be avoided, whereas at sea, once a ship is contaminated, the personnel must not only continue to fight in the contaminated area, but will be forced to eat, sleep, rest, and live in it until decontaminated.

The medical officer must be familiar with the tactics of chemical attack and the methods of defense to lessen or neutralize its effect. He must realize that the most effective gas defense for personnel demands fearless action, the best possible use of protective equipment, and, when exposed, prompt self-aid.

The medical officer afloat must be acquainted with the *damage control organization* of the ship. He must formulate his plans accordingly and in conformity with the necessary compromise between the function of the ship as a combat unit and the effective handling of casualties when they occur. Stations for the decontamination of wounded gas casualties must be so placed as to be available quickly without contaminating otherwise clean passageways and compartments.

The medical officer attached to shore activities must appreciate the problems specific to such activities. He must devise plans for the care of gassed cases with additional injury whether they be in forward areas or on shore stations within range of gas attack. Undue delay in decontamination must be avoided and gas-contaminated personnel must be denied admission to medical installations not specifically designated to handle such cases.

The purpose of this manual is to acquaint medical personnel with the treatment of casualties produced by chemical agents.

2. CLASSIFICATION OF AGENTS

Chemical warfare agents are classified according to their physiological action, persistency, and tactical use.

A. Classification by Physiological Action

(1) Lung irritants (choking gases) primarily irritate and damage the respiratory tract. Example: Phosgene (CG).

(2) Vesicants (blister gases) injure the eyes, produce reddening and blistering of the skin, and when inhaled damage the respiratory tract. Example: Mustard (H).

(3) Lacrimators (tear gases) act primarily on the eyes, causing tears and intense, though temporary, pain. Example: Chloracetophenone (CN).

(4) Irritant smokes or sternutators (vomiting gases) irritate the nose, throat and eyes. They may produce temporary prostration. Example: Diphenylaminechlorarsine (adamsite) (DM).

(5) Systemic poisons (blood and nerve poisons) stop essential physiological processes. Example: Hydrocyanic Acid (AC).

B. Classification by Persistency

The ability of an agent to maintain an effective concentration under field conditions is called its persistency.

(1) Persistent agents maintain effective concentrations longer than 10 minutes, and then may last for days or weeks. They are used to neutralize or force evacuation of certain areas. Example: Mustard (H).

(2) Nonpersistent agents maintain effective concentrations less than 10 minutes. They do not render ground untenable after the cloud has passed. Example: Phosgene (CG).

C. Classification by Tactical Use

(1) Casualty agents injure personnel. Example: Mustard and Phosgene.

(2) Harassing agents force the wearing of masks and thus impede operations. Example: Irritant Smoke (DM and DA).

(3) Screening agents produce obscuring smoke to prevent observation. Example: White Phosphorus (WP).

(4) Incendiaries ignite matériel and produce burns on personnel. Example: Thermite (TH).

3. FUNDAMENTALS OF SELF-AID AND TREATMENT

A. Self-Aid the All-Important Factor

Immediate self-aid or personal decontamination following contamination with liquid blister gases is the all-important factor in reducing the number of casualties since there are definite time limits after which these measures are useless. Decontamination combines both neutralization and removal of the agent before serious injury occurs. Unless incapacitated, each man will care for himself. If the individual cannot decontaminate himself, his closest shipmate may assist him.

(1) If the individual has been contaminated by liquid blister gas, as from an airplane spray or bomb burst, he will be confronted with the problem of carrying out several self-aid or protective measures as rapidly as possible. With due regard to the practicability of carrying out these measures under the existing tactical situation, the following order of procedure is recommended:

(a) Apply self-aid measures for the eyes contaminated with liquid blister gas and follow by decontamination of the face. Hold the breath until masked if at all possible.

(b) If wearing eyeshields, remove and discard. Decontaminate the face and then apply gas mask. Hold the breath until masked, if at all possible.

(c) Remove or cut away clothing which is heavily contaminated with liquid blister gas.

(d) Decontaminate areas of skin which have been contaminated by liquid blister gas.

B. Individual Responsibility

Self-aid or personal decontamination is the individual responsibility of all Navy and Marine Corps personnel. If battle conditions at the time of exposure compel uninterrupted manning of guns and stations, then personal decontamination shall be accomplished at the earliest possible moment when tactical conditions permit. It is a cardinal principle of protection that no contamination, under any circumstances, will be carried inside enclosed spaces, or below decks in naval vessels.

C. Definitive Treatment

Definitive treatment is designed to promote healing after injury has occurred and should be distinguished from self-aid. This is the function of the medical department. Individuals will report to the medical services only when they become casualties, whether from chemicals or other weapons of war.

LUNG IRRITANTS

4. GENERAL

The most important lung irritants are phosgene, chlorpicrin and chlorine. In general, the gases which are the most irritating, such as chlorine and chlorpicrin, are most likely to injure the trachea and bronchi, but also may cause pulmonary edema. Phosgene which is less irritating produces its major effect on the lungs and causes pulmonary edema. Vesicants, certain systemic poisons, and certain incidental gases also damage the respiratory tract. (See secs. III, VIII, IX.)

Personnel exposed to a lung irritant gas need not be withdrawn during combat unless signs of pulmonary distress are apparent. The medical officer should so advise the responsible commanding officer.

Any service mask or the collective protector affords adequate protection. On detection, hold the breath instantly, don the mask, and exhale as completely as possible. Speed is imperative.

5. PHOSGENE (CG)

A. Pathology

(1) Aside from mild conjunctival irritation, the direct effects of exposures to phosgene gas are confined to the lungs. Changes in other organs are secondary to the pulmonary alterations and are relatively unimportant. The outstanding pathologic feature in the early stage is *massive pulmonary edema;* this results from the passage of fluid into the alveoli from capillaries whose permeability has been affected by the action of the agent. It is preceded by damage of the bronchiolar epithelium, the development of patchy areas of emphysema and partial atelectasis, and edema of the perivascular connective tissue. The epithelium of the trachea and larger bronchi is not significantly damaged. Grossly, the lungs are large, edematous, and darkly congested; edema fluid, usually frothy, pours from the bronchi and exudes from the sectioned lung tissue.

(2) Hemoconcentration results from the loss of plasma into the alveoli. The edema usually reaches a maximum 12 to 24 hours after gassing, and results in interference with the interchange of oxygen and waste products between the alveolar air and the capillary blood, so that in most instances of lethal exposure, death occurs within the first 24 or 48 hours from the resulting *anoxemia.* With very high exposures, death may ensue in 5 hours, or possibly even less. In sur-

viving individuals the edema begins to resorb after about 48 hours and, in the absence of complicating infection, recovery may take place with practically complete resolution of the lesion. Should this process be complicated by secondary bacterial infection of the lungs, the clinical signs of a purulent bronchitis and bronchopneumonia will be apparent at about 3 to 5 days. In some cases there may be focal intrabronchial and peribronchial fibrosis as a result of the initial damage to the bronchiolar walls. Investigations have shown that in recovered individuals the percentage of cases showing significant residual lesions is small. Such lesions as were found following gassing in World War I consisted chiefly of instances of chronic emphysema, chronic bronchitis, bronchiectasis, and pulmonary fibrosis.

B. Symptoms

Immediately after exposure there is likely to be coughing, choking, a feeling of tightness in the chest, nausea, and occasionally vomiting, headache, and lacrimation. The presence or absence of these symptoms is of little value in immediate prognosis, as some patients with severe cough fail to develop serious lung injury, while others with no signs of early respiratory tract irritation go on to fatal pulmonary edema. There may be slowing of the pulse initially, followed usually by an increase in rate. A period follows during which abnormal chest signs are absent and the patient may be symptom-free. This interval commonly lasts 2 to 24 hours, but occasionally is shorter. It is terminated by the signs and symptoms of pulmonary edema. These begin with rapid shallow breathing, painful cough, and *cyanosis*. Nausea and vomiting may appear. As the edema progresses, discomfort, apprehension, and dyspnea increase and much frothy sputum is raised. Rales and rhonchi are audible over the chest, and breath sounds are diminished. The patient may develop a shocklike state, with leaden, clammy skin, low blood pressure, and a feeble heart.

C. Diagnosis

Irritation of the nose and throat by phosgene may be mistaken for an upper respiratory tract infection. Difficulty in breathing and complaint of tightness in the chest may suggest an acute asthmatic attack. The pulmonary edema is like that produced by many other war gases and may be confused with the edema associated with heart failure. Diagnosis can be established with certainty only from a definite history of exposure to phosgene, the odor suggesting musty or burned hay, silage, or green corn.

D. Treatment

(1) *Rest:* Pending the appearance of definite symptoms, men may continue their duties. When symptoms of respiratory distress appear, the patient should be evacuated by *litter*.

(2) *Warmth:* Phosgene casualties should be kept only comfortably warm.

(3) *Oxygen therapy:* Anoxia should be treated with oxygen. The need for oxygen is indicated by cough, dyspnea, cyanosis, and restlessness. Oxygen should be administered in as high a concentration as possible, in any case high enough to eliminate cyanosis. Oxygen decreases anoxia and quiets the patient. It is best administered by a mask which allows regulation of the proportion of oxygen and air. Lower and less well controlled concentrations are obtainable in tents and with nasal catheters. Carbon dioxide-oxygen mixtures are not indicated in phosgene poisoning.

(4) *Venesection:* There is at present no definite evidence that venesection is beneficial at any time; it is certainly harmful during the shocklike state.

(5) *Sedation:* If cough is a prominent symptom, codeine in doses of 0.032 to 0.064 grams (grains ½ to 1) is effective. If oxygen fails to quiet the patient, morphine may be used subcutaneously in a dose of 0.010-0.015 grams (grains 1/6 to ¼). The physician must weigh the value of its sedative effect against its depression of respiration. Sedative doses of barbiturates are ineffective and larger doses may be harmful.

(6) *Specific antibacterial therapy:*

(a) Specific antibacterial therapy should not be given during the latent period. Thereafter, it may be administered for the prevention of pulmonary infection as soon as the edema begins to subside, as evidenced by an improvement in the patient's general condition. Decision as to the prophylactic use of specific therapy following exposure to lung irritants will be dependent in part upon the estimated severity of the lung damage and in part upon the season of the year, the locality, and the prevalence of respiratory infections. The drug of choice is penicillin which, when available in adequate amounts, will be used in all cases of this type in which specific therapy is considered desirable. A suggested dosage schedule is 15,000 Oxford units intramuscularly every 3 hours for a minimum of 4 days, making a minimum total dose of 480,000 Oxford units. Prolongation of the treatment will be determined by clinical evaluation of the individual patient.

(b) If penicillin is not available, sulfadiazine will be used when specific antibacterial therapy is deemed desirable. Like penicillin, sulfadiazine will be used only when the severity of the lung damage or other considerations indicate the probability of development of pulmonary infection if specific therapy is withheld. When sulfadiazine is used, it should be prescribed in adequate dosage. A suggested schedule is 4 grams (grains 60) as an initial dose, and 1 gram (grains 15) every 4 hours thereafter for a minimum of 4 days, but longer when necessary. The usual precautions to prevent the complications of sulfonamide therapy must be observed. The daily urine output must be maintained above 1500cc. and the urine should be kept alkaline by the administration of sodium bicarbonate (4 grams with the initial dose of sulfadiazine and 2 grams every 4 hours thereafter). Alertness must be maintained to detect any signs of drug toxicity through repeated blood counts, urinalysis, and inspections of the patient for signs of a skin rash. Evaluation of a low grade

fever in these patients is difficult since the fever may be caused by absorption of the break-down products of necrotic tissue, infection, or drug reaction.

(c) If pulmonary infection appears, as evidenced by an increase of the body temperature or change of chest signs, penicillin or sulfonamides must be used in the dosage outlined in paragraphs 6a and 6b.

(7) *Expectorants:* Expectorants should not be used in the treatment of phosgene poisoning.

(8) *Other measures:* Atropine does not diminish edema or improve breathing; its acceleratory action on the heart is undesirable. Plasma is of no value in the treatment of phosgene poisoning. Infusions pass readily into the lungs and increase the edema. Concentrated plasma is even more harmful. Surgery, except emergency measures to save life, is contraindicated in the active stage of edema. If anesthesia is required, local infiltration or nerve block is the method of choice. Cardiac and respiratory stimulants, such as adrenalin, ephedrine, benzedrine, coramine, and metrazol do more harm than good. Alcohol is contraindicated.

E. Convalescent Care

Absolute rest must be continued until the acute symptoms have disappeared. As recovery progresses, exercise should be resumed gradually. Sitting in bed should be permitted first, then for brief intervals in a chair. Bathroom privileges should follow and then short periods of alternate walking and resting. Later the convalescent should walk increasing distances.

F. Prognosis

Prognosis should be guarded because of the insidious nature of the poisoning. Most deaths occur within the first 48 hours. The few which occur later are due largely to bronchopneumonia. Casualties from phosgene which survive more than 48 hours usually recover without sequelae. Rarely do chronic bronchitis and bronchiectasis result. The incidence of tuberculosis is no greater in those poisoned by phosgene than in the general population.

6. CHLORPICRIN (PS)

A. Pathology

As a rule, chlorpicrin has been used in warfare in combination with other agents. When used alone, its effects on the lung are quite similar to those of phosgene. Apart from the difference in toxicity, chlorpicrin may produce almost as severe pulmonary edema as phosgene. There may be even more severe necrosis of the bronchiolar epithelium than is produced by phosgene, and in addition, focal necrosis of the epithelium of the trachea and large bronchi, although in this respect the action of chlorpicrin is much less marked than that

of chlorine. The course of events following the inhalation of chlorpicrin is essentially the same as that following phosgene. Chlorpicrin vapor irritates the conjunctiva, and severe exposures may result in corneal injury. It is also irritating to the skin, and contamination of the skin with liquid chlorpicrin may result in deep burns.

B. Symptoms

Irritation of the eyes is the first symptom noted, as chlorpicrin is a strong lacrimator. This is frequently followed by pain in the chest, cough, nausea, and vomiting. Severe exposure causes pulmonary edema, like that produced by phosgene, and generalized muscular weakness, with feeble heart action. Repeated small exposures increase susceptibility to asthmatic attacks from traces of this gas.

C. Diagnosis

Diagnosis can be established by a history of exposure, a characteristic flypaper odor on clothing, and the symptoms described above.

D. Treatment

Irritation of the eyes and nose can be relieved by irrigation with water, followed by the instillation of butyn, ophthalmic ointment, or a few drops of anesthetic solution. Inhalation of steam relieves the trachea bronchial irritation. Codeine helps to allay the cough. If pulmonary edema develops, it is treated like that caused by phosgene. (See par. 5D.)

E. Prognosis

Most deaths occur in the first 24 hours; if later, they are usually due to bronchopneumonia. Casualties surviving this period generally recover without sequelae.

7. CHLORINE (CL)

Chlorine is very irritating to the respiratory tract. It produces damage which may result in necrosis of the mucous membrane of the trachea, bronchi, and lungs. Pulmonary edema occurs, similar to that caused by phosgene. After exposure, the initial symptoms are burning of the throat, violent coughing, a feeling of suffocation, nausea, and occasionally vomiting. Pulmonary edema follows sometimes within 20 minutes. The history and the intense irritation of the nose and throat are aids to early diagnosis. The treatment of chlorine poisoning is the same as that outlined for chlorpicrin. (See par. 6D.)

SECTION III

VESICANTS (BLISTER GAS)

8. GENERAL

The vesicants act primarily on the eyes and skin. In addition, they damage the respiratory tract when inhaled and, when absorbed, they cause systemic poisoning. The nitrogen mustards and the arsenical vesicants are the most dangerous in this last respect.

Vesicants poison food and water and render other supplies dangerous to handle.

Casualties contaminated with vesicants endanger unprotected attendants. Those in contact with such patients should wear, at least, protective masks, impermeable aprons and gloves, and other protective clothing if the area is contaminated. Exposed areas of the skin should be covered with protective ointment, S–461 or S–330 (latter preferred).

Special precautions must be taken in receiving contaminated casualties to prevent injury of others. These casualties should be undressed in the open to prevent vapor accumulation indoors. They should be kept separated from uncontaminated patients until decontamination is complete. Contaminated litters, blankets, and equipment should be left outdoors. It is necessary to decontaminate equipment and ambulances after transporting such casualties. (See sec. XIII.)

Identification of the agent is important in order to apply specific treatment. (Identification of the agent may not be possible in the field. All contaminations are treated by *one standard procedure* unless directed otherwise by local authority.) (See par. 14B(1)(2), p. 28.)

Any service mask protects only the face, eyes, and respiratory tract. The eyeshield protects the eyes from contamination by liquid, but not from vapor. Impregnated protective clothing prevents the vesicant from reaching the skin. Large drops of blister gas exhaust the impregnite in the clothing at the point where the liquid wets the fabric and some of the agents will penetrate to the body of the wearer. Protective ointment, S–461 or S–330 prevents mustard gas from reaching the skin covered by the ointment.

9. MUSTARD (H)

A. Properties

Mustard is an oily liquid heavier than water. It ranges from colorless when pure to dark brown when plant-run. Its odor is like garlic or horseradish. It is only slightly soluble in water, which gradually

destroys it, but undissolved mustard may persist in water for long periods. It is more soluble in fats and oils, and freely soluble in gasoline, kerosene, acetone, carbon tetrachloride, and alcohol. These solvents do not destroy mustard. From contaminated ground or materials mustard disappears through evaporation or through hydrolysis. It can be destroyed rapidly by decontaminating chemicals or by boiling. It is slowly absorbed by rubber articles and so may contaminate their inner surfaces. The persistence of hazard from mustard vapor or liquid depends on the degree of contamination by the liquid, the type of mustard, the nature of the terrain and of the soil, the type of munition used to disperse the mustard, and the weather conditions. The persistence of mustard in wooded areas may be much longer than in the open. In winter, mustard persists two to five times as long as in summer and the hazard from the vapor is many times greater under hot than under cool conditions. Concentrations of mustard vapor should be estimated in the field by gas detector kits, paper, crayon, and paint detectors. (See p. 157, Defensive Chemical Warfare Manual, FTP 222, United States Fleet.)

B. Eye

(1) *Pathology, symptoms, and prognosis.* (See figs. 2 and 3):

(a) The eye is more vulnerable to mustard than either the respiratory tract or the skin. After an exposure of 2 hours to a concentration barely perceptible by odor, eye lesions may follow. (0.001 mg. per liter.) This exposure does not significantly affect the respiratory tract or skin.

(b) A latent period of 4 to 12 hours follows mild exposure, after which there is lacrimation and a sensation of grit in the eyes. The conjunctivae and lids become red and edematous. Heavy exposure irritates the eye after a shorter latent period, and produces more severe lesions. Mustard burns of the eye may be divided into groups as follows:

1. Mild conjunctivitis (75 percent of cases in World War I). Recovery in 1 to 2 weeks.

2. Severe conjunctivitis with minimal corneal involvement (15 percent of cases). Blepharospasm, and edema of lids and conjunctivae; orange-peel roughening of the cornea. Recovery in 2 to 6 weeks.

3. Mild corneal involvement (10 percent of cases). Areas of corneal erosion staining green with 2 percent of fluorescein. Superficial corneal scarring and vascularization. Iritis with a tendency to temporary relapses. Convalescence requires 2 to 3 months. This group requires base hospital care.

4. Severe corneal involvement (approximately 0.1 percent of cases). Ischemic necrosis of conjunctivae. Dense corneal opacification with deep ulceration and vascularization. Convalescence requires several months. Predisposition to late relapses.

(2) *Decontamination of the eyes:*

(a) *Vapor.* When the eyes are exposed to mustard vapor alone, no decontamination procedure is of any value. The gas mask should be put on immediately.

(b) *Liquid.* (1) The eye shields, supplied to each individual, shall be worn at all times during periods of gas hazard. This prevents contamination of the

eye for spray and splashes of liquid blister gases. Periods of hazard would include the handling of vesicant munitions, the use of blister gas in training programs, and at all times when in the open and within range of enemy aircraft after chemical warfare has been initiated. *The eye shields, properly used, constitute the real solution to the problem of eye injuries due to blister gases.* If the eye shield is worn it must be discarded after contamination.

(2) *All* contaminations of the eyes by *any* liquid blister gas whether mustard, nitrogen mustards, lewisite, (or other arsenical vesicants) or mixtures thereof are decontaminated by *one standard procedure.* This combines the use of BAL ointment, massage, and irrigation. An individual issue of ointment BAL (½-ounce tube) is made to all men in combat zones as issued in J15 A and B components. Immediately after contamination by any liquid blister gas BAL ointment is squeezed directly into the lower eyelid. If the eye cannot be opened, after contamination by lewisite, either alone or in mixtures, the ointment is applied to the eyelids and rubbed well. Sufficient ointment will enter between the lids to relieve pain and spasm to such an extent as to make it possible to open the eye. Ointment shall then be instilled directly into the lower sac. The lids are then closed and massaged for 1 minute. This is followed by irrigation of the eye with water from the canteen or other available uncontaminated source. The head is thrown back, the lids are forced open with fingers of one hand, while the water is poured into the eye from a container in the other hand. The water shall be poured directly and slowly into the eye *for at least ½ minute,* or until the canteen is empty, but not longer than approximately *2 minutes.* If BAL ointment is not immediately available, the eye shall be irrigated immediately with water without waiting to obtain the ointment. The decontamination must be completed before the gas mask is put on in spite of possible exposure to vapor during decontamination. Therefore, the individual should hold his breath as long as possible until the treatment is completed and the gas mask can be adjusted.

In contaminations by liquid mustard the initiation of self-aid within the first few seconds is markedly effective and after 2 minutes is of very little value. (Note: The fact that the individual tubes of BAL ointment do not have printed on them directions for use against mustard, nitrogen mustards, and mixtures of these with lewisite is not to be construed as a contraindication to its use against these agents in the eye.)

(3) Liquid mustard alone in the eye causes no immediate pain or discomfort, but when BAL ointment is placed into an eye contaminated with this agent alone, there will be immediate irritation and spasm. *This is to be expected and personal decontamination or self-aid should not be stopped because of it.* The irritation from the ointment ceases as soon as the irrigation is begun. However, the irrigation should not be stopped as soon as the stinging disappears, but should be continued for 30 seconds to 2 minutes.

(4) BAL ointment placed in an uncontaminated eye is very irritating and causes immediate stinging and spasm which may interfere with the individual's combat ability for a period up to 15 minutes. Therefore, the ointments should be used in the eye only when the individual is fairly certain that his eye has been contaminated by some form of liquid blister gas. The chance of liquid contamination is slight except when in the close vicinity of a shell or bomb burst, or in the path of a direct airplane spray.

(5) Previous manuals and directives have stated that irrigation alone should be used as self-aid or personal decontamination for liquid mustard contamination of the eye. Recent studies have shown that BAL ointment followed by irrigation is superior to irrigation alone. A further advantage of this new

self-aid procedure is that since it is used for *all* liquid blister gas contaminations of the eye, the individual has to remember only *one* self-aid procedure. He is therefore not compelled to distinguish between different contaminating agents at a time when this might be impossible. Therefore, previous directives and manuals are to be disregarded in favor of the method described above.

(6) In contamination of the eye by liquid mustard alone, the initiation of self-aid within the first few seconds is markedly effective and after 2 minutes is of very little value. In the case of contamination of the eye by liquid lewisite or any other arsenical vesicant, BAL ointment is effective for a longer period of time. If it is used within 1 minute after contamination, the eye usually recovers in a few days. When it is used 10 minutes after contamination, the eye requires several weeks to heal and usually suffers permanent damage. BAL ointment has almost no effect after 30 minutes.

(7) *Decontamination of eyelashes and lids:* The lids, lashes, and skin areas close to the eyes are best decontaminated by washing with soap and water. Protective ointment S-461 or S-330 is irritating to the eyes. If water is not available, liquid vesicants may be removed from the lids by dabbing carefully with a cloth or other absorbent.

(8) *Treatment of mustard conjunctivitis:* (a) Mild lesions require little treatment. Although they seldom become infected, 3 percent sodium sulamyd solution, where available, two drops instilled every 4 to 8 hours, has an analgesic action and aids in preventing sepsis. Butyn opthalmic ointment, or anesthetic solution may be instilled for added comfort. If the lids tend to stick together during sleep, sterile petrolatum may be applied to the lid margins.

(b) More severe injuries will cause enough edema of the lids, photophobia, and blepharospasm to obstruct vision. This is very alarming to the patient, consequently the lids should be gently forced open to assure the patient that he is not blind. Pain may be allayed temporarily by butyn opthalmic ointment, or drops of anesthetic solution, but these drops, or other local anesthetics, should not be used persistently. It is best to control the pain by morphine and other systemic sedation. All patients having severe photophobia and blepharospasm should have 1 drop of atropine solution, 1 percent, instilled into the eye 3 times a day.

(c) To prevent infection, a few drops of 3- to 10-percent solution of sodium sulamyd should be instilled every 4 hours. Penicillin sodium solution, 1000 units per cc., or sulfathiazol ophthalmic ointment may be substituted for sodium sulamyd. The eye must not be bandaged or the lids allowed to stick together. Sealing of the lids may be prevented by the application of sterile petrolatum to the lid margins. The accumulation of secretions in the conjunctival sac, or pressure on the eye, predisposes to corneal ulceration. Irrigations should be gentle and must be held to the minimum necessary to remove secretions. Copious irrigation should be avoided as it tends to loosen and remove injured corneal epithelium. Isotonic or slightly hypertonic sterile solutions must be used, never hypotonic solutions; 1 percent saline is satisfactory. When the lids can be opened sufficiently for an ophthalmic examination, the cornea should be stained with fluorescein and one drop of 2-percent solution in saline placed into the lower conjunctival sac. The eye should then be rinsed with a few drops of sterile saline and examined for yellowish-green staining of the cornea. Staining indicates damage to, or loss of, epithelium. If the cornea stains, or if severe photophobia persists, the patient should be transferred to the care of the ophthalmologist. When possible the patient should be kept in

a darkened room. Dark glasses or an eye shade may be worn for photophobia, but should be discarded as soon as possible to prevent psychologic sequelae.

(9) *Treatment of infected mustard burns of eye:* Secondary infection is a serious complication and increases the amount of permanent scarring of the cornea. If infection develops, the eye should be treated with several drops of a 10-percent solution of sodium sulamyd every 2 hours, or penicillin sodium, 1000 units per cc., every 4 hours, or sulfathiazol ophthalmic ointment every 4 hours. Irrigation should be gentle and employed only to remove accumulated exudate. Pain is controlled as described above. Patients with secondary infection or other complications should be referred to the ophthalmologist. Local anaesthesia should not be used unless necessary and not oftener than every 6 hours.

C. Skin

(1) *Pathology:* The severity of the lesions and the rapidity with which they develop are greatly influenced by weather conditions as well as by the degree of the exposure. Hot, humid weather strikingly increases the action of mustard. Even under temperate conditions, the warm, moist skin of the perineum, external genitalia, axillae, antecubital fossae, and neck are particularly susceptible. (See figs. 9, 10, 31, 32 and 33.)

(a) *Latent period:* After exposure, there is a latent period which varies with the degree of exposure. It may be as short as an hour with liquid contamination when the weather is hot and humid, or as long as several days with mild vapor exposures. With most vapor exposures in temperate weather, the latent period usually lasts 6 to 12 hours.

(b) *Erythema:* (See figs. 6A, 7A, and 7B.) Erythema gradually appears and becomes brighter, resembling sunburn. Microscopically, there is capillary hyperemia in the corium, accompanied by a variable degree of dermal edema. In severe burns the latter may be considerable, and limit motion of a limb.

(c) *Vesication:* (See figs. 4, 5, and 8.) Except with mild vapor burns, erythema is followed by vesication. This is caused by progressive development of liquefaction necrosis of cells in the lower layers of the epidermis. Exudation of tissue fluid into the spaces so formed results in an intraepidermal vesicle. Clinically, multiple pinpoint lesions may be seen to arise within the erythematous skin; these enlarge and coalesce to form the typical blister which is usually large, domed, thin-walled, superficial, translucent, yellowish, and surrounded by erythema. The blister fluid is clear, at first thin and straw-colored, later yellowish and tends to coagulate. It is completely non-irritating. Liquid contamination of the skin usually results in a ring of vesicles surrounding a gray-white area of skin which, though necrotic, does not vesicate.

(d) *Resorption:* If the blister does not rupture, resorption takes place in about a week. The roof forms a crust, beneath which re-epidermization takes place. However, because of their thinness and tenseness, the blisters are fragile and usually break. If the roof becomes ragged, the burn may be considered an open wound. Such lesions may become secondarily infected.

(e) *Healing:* Inasmuch as the damage to the corium is relatively superficial except in severe burns, healing takes place with little or no scar tissue formation except in very severe or infected burns.

(f) *Pigmentation:* Mustard burns usually are followed by a persistent brown pigmentation, except at the site of actual vesication, where there may be a temporary depigmentation.

(g) *Hypersensitivity:* Repeated burns may lead to hypersensitivity of the skin to mustard.

(2) *Symptoms and prognosis:*

(a) An outstanding characteristic of the action of mustard is its *insidiousness.* Exposures to mustard are not accompanied by symptoms, nor do any local manifestations occur until the development of erythema when there may be itching and mild burning. This pruritus may last for a number of days and even after healing. The blisters may be painful.

(b) Very mild mustard burns heal within a few days. Burns of moderate severity heal usually within 2 to 4 weeks. Severe or infected burns may require 6 to 8 weeks or even longer to heal.

(3) *Diagnosis of skin lesions due to mustard:*

Similar skin burns are produced by mustard and the nitrogen mustards. Mustard burns are also similar in appearance to those due to lewisite and other arsenical vesicants. Differentiation of mustard lesions from those produced by lewisite is based upon:

(a) History of exposure to mustard.

(b) Absence of pain or discomfort at time of contamination. (Lewisite is irritating or painful immediately.)

(c) Wide zone of erythema surrounding blisters. (Lewisite, not prominent.)

It should be remembered that vesicular lesions, much like mild mustard burns, may be produced in sensitive individuals by a variety of substances, notably plant poisons such as poison ivy or poison oak.

(4) *Treatment of mustard erythema:*

Mustard erythema in mild cases requires no treatment. If annoying itching is present, considerable relief can be obtained with calamine lotion. Calamine lotion, NF, with 0.5 percent each of phenol and menthol. Severe erythema is often accompanied by edema, stiffness, and pain. Painful erythema of the genitalia may be treated with calamine lotion and a suspensory bandage. Alternatively, petrolatum, a light protective dressing, and suspensory may be used.

(5) *Treatment of mustard blister:*

(a) Blisters should be treated by application of sterile petrolatum dressings. Frequent changes of dressing are undesirable. The dressing should be left in place as long as possible (up to 2 weeks). Small blisters of the face are best left alone. Large blisters may be covered with a sterile petrolatum dressing. Burns of the genitalia may be treated with a sterile petrolatum dressing and suspensory, using a minimum of petrolatum to avoid undue moisture with resulting excoriation.

(b) If the dressing sticks to the wound, care will be necessary to avoid pulling off the blister top. It is good practice to trim the edges of the adherent gauze, leave it in place, and put a fresh dressing over it. If necessary to examine the wound, the dressing can be soaked off.

(6) *Treatment of denuded areas:*

(a) The same sterile technic as for thermal burns (see sec. XII), including face masks, should be employed. Frequent change of dressing is to be avoided.

(b) Blistered areas which have become denuded may be treated with sterile petrolatum as for thermal burns. (See sec. XII.)

(c) Strong antiseptics and escharotics of all kinds are contraindicated.

(d) Other phases of the late treatment are similar to those described in the treatment of thermal burns. Thus, occasional extensive granulating surfaces may require skin grafting. Multiple pinch grafts have proved successful.

(7) *Treatment of infected mustard burns:*

(a) Contamination of mustard burns with saprophytic bacteria is common, but not serious. If there is no inflammatory reaction, the treatment is the same as for uncontaminated burns. (See sec. XII.)

(b) Infected burns showing inflammatory reaction should be considered infected wounds. They may be treated locally by the use of sterile petrolatum with proper cleansing and drainage, or hot sterile saline dressings.

(c) Strong local antiseptics and escharotics are contraindicated.

(8) *Specific anti-bacterial therapy:*

(a) When indicated, specific antibacterial therapy should be instituted. Penicillin is the drug of choice and should be given intramuscularly in doses of 25,000 units every 3 hours as long as indicated. For cases in which sulfadiazine is used, it should be given orally with an initial dose of 4 grams (grains 60), and 1 gram (grains 15) every 4 hours thereafter. Sufficient fluids should be given to maintain the output of urine over 1500 cc. (1½ quarts) daily. Four grams (grains 60) of sodium bicarbonate should be given with the initial dose of sulfadiazine and 2 grams (grains 30) every 4 hours thereafter to keep the urine alkaline.

D. Decontamination of Skin.

(1) *Personal decontamination or self-aid is an individual responsibility of all Navy and Marine Corps Personnel:* Only casualties who are unable to decontaminate themselves are cared for by the medical service.

(2) Personal decontamination is the removal of liquid mustard at the earliest possible instant. The importance of prompt action cannot be overstressed. Proper skin decontamination for mustard during the first minute is always successful. After 3 minutes on the hot sweaty skin, or 5 minutes on the cool dry skin, no method of decontamination will prevent blistering. Decontamination should be performed, however, no matter how delayed, as long as liquid mustard is still present as it may be of some value. Decontamination is of no value after vapor exposure.

(3) Protective ointment, S–461 or S–330 (the latter being preferred) will protect against liquid blister gas for a short time. Areas of skin contaminated with liquid blister gas, whether protected by the ointment, or unprotected must be decontaminated as soon as possible. The free liquid blister gas is blotted from the skin with the absorbent cloth wrapped around each tube of ointment or by using any absorbent material at hand. *Discard the used absorbent.* Ointment is then applied freely to the area with the fingers for about 15 seconds. The excess is immediately removed, more ointment reapplied and allowed to remain. If contamination with blister gas is light, no blotting is necessary but generous application of protective ointment, S–461 or S–330 with thorough rubbing will be sufficient.

(4) If reddening of the skin has appeared before decontamination with protective ointment (S–461 or S–330) has been conducted, cleanse the area with soap and water. Protective ointment is irritating to the reddened skin and shall be used only when liquid mustard is still present and soap and water are not available for thorough washing. Solvents should not be used if soap and water are available.

(5) Should the supply of protective ointment run short, the following alternatives may be employed:

(a) *Bleach paste:* Prepared by mixing one part bleach and two parts of water. Because of its irritant properties, it must be washed off the skin within 3 minutes.

(b) *Solvents:* Any nonirritant organic solvent may be used in an emergency to dissolve and dilute the liquid mustard. Since solvents do not neutralize the vesicant, the mustard solution formed must be completely and rapidly removed from the skin by flooding with a large excess of the solvent. Alternatively, the area may be sponged repeatedly with cotton or gauze dampened with solvent, with care to avoid the spread of mustard from contaminated skin. Gasoline, kerosene, alcohol, and carbon tetrachloride (from automobile fire extinguishers) are most commonly available. (*Caution:* Precautions against fire and explosion must be observed when employing inflammable solvents.) Leaded gasoline and carbon tetrachloride when absorbed by the body are poisonous.

(6) The decontaminated skin areas should be thoroughly washed with soap and water as soon as practicable after decontamination.

(7) Wounded cases, with liquid mustard contamination of the skin, will seldom be received at battle dressing stations on ships or at shore medical installations in time to prevent subsequent blistering. Nevertheless, if erythema has not appeared, known or likely areas of contamination should be decontaminated as outlined in the preceding paragraphs.

E. Decontamination of Hair

The contaminated hair may be clipped off, or decontaminated with bleach paste. The scalp should then be washed with soap and water. Protective ointment may be used, but it is difficult to apply and remove.

F. Respiratory Tract

(1) *Pathology:*

(a) Inhalation of mustard vapor causes damage primarily to the laryngeal and tracheobronchial mucosa, which develops slowly after the exposure. Minimal amounts of vapor may be inhaled without significant damage. More severe exposures result in hyperemia of the respiratory mucous membrane and necrosis of the lining epithelium. With severe exposures, the necrotizing action is accompanied by exudation which results in a diphtheritic like pseudomembrane which may form a cast of the tracheobronchial tree.

(b) In the more severe cases, the pulmonary parenchyma shows congestion, mild patchy edema, moderate acute emphysema, and focal atelectasis. Altogether, these changes are insufficient to cause anoxia, but they are fre-

quently complicated by bacterial infection of the lung which results in suppurative bronchitis and bronchopneumonia. The latter is responsible for almost all deaths following vapor exposures. The mortality from mustard in the American Expeditionary Force, slightly more than 2 percent, was almost entirely from such complication following inhalation of vapor.

(2) *Symptoms and prognosis:* Respiratory tract lesions, like skin injuries, develop slowly and do not reach maximal severity for several days. Symptoms begin with hoarseness which may progress to aphonia. A cough appears early and becomes productive. Fever, dyspnea, and moist rales may develop. The incidence of bronchopneumonia is high. Convalescence is slow, and cough may persist a month or longer. Milder symptoms, like hoarseness, last only a week or two.

(3) *Treatment of respiratory tract injury due to mustard:* Mild respiratory tract injury, with hoarseness and sore throat only, usually requires no treatment. Cough may be relieved by codeine, and pharyngitis with alkaline gargles. Relief from nasal irritation may be obtained with nose drops of anesthetic solution. Since severe respiratory tract injuries predispose to bronchopneumonia, when clinical evidence of such injury becomes manifest, the prophylactic intramuscular administration of penicillin or oral administration of sulfadiazine is indicated. (See par. 5D(6), p. 6.) Laryngitis and tracheitis should be treated with steam inhalations. Morphine or the barbiturates can be used to quiet the patient. Secondary bronchopneumonia should be treated like any other bronchopneumonia.

G. Systemic and gastro-intestinal

(1) *Symptoms:*

(a) Ingestion of food or water contaminated by liquid mustard produces nausea and vomiting, pain, diarrhea and prostration. Mustard vapor does not significantly contaminate food or water.

(b) Exposure of the skin alone to mustard may cause systemic symptoms such as malaise, nausea, vomiting, and fever, coming on at about the time of onset of the erythema. With severe exposures, particularly extensive liquid contamination of the skin, these symptoms may be so marked as to result in prostration. Exceptional cases of severe systemic mustard poisoning may also present central nervous symptoms such as cerebral depression, and parasympathomimetic effect such as bradycardia and cardiac irregularities. Cerebral excitation and salivation have been observed in animals, as well as bloody diarrhea and excessive loss of fluid and electrolytes. Hemoconcentration and shock may occur. It must be emphasized that such severe systemic effects do not occur with ordinary mustard exposures.

(2) *Pathology*: With ordinary skin or respiratory exposures to mustard, no apparent systemic lesions develop. With amounts approaching a lethal dose, injury to the hematopoietic tissues (bone marrow, lymph nodes and spleen) may result. Such hematopoietic damage is reflected in the peripheral blood by leucopenia and thrombocytopenia,

(3) *Treatment:*

(a) In the treatment of the systemic symptoms, atropine subcutaneously (0.6 mg. (1/100 grains)) may prove useful in reducing the gastrointestinal activity. The general discomfort and restlessness may require large doses of sedatives, for which the barbiturates and morphine may be indicated. In the exceptional cases of severe systemic poisoning with vomiting and diarrhea, leucopenia, hemoconcentration, and shock, every effort should be made to maintain an adequate nutritional status and replace the loss of fluid and electrolytes by transfusions of whole blood or plasma, and infusions of dextrose and saline. Paregoric and bismuth subcarbonate can be used for the relief of diarrhea.

(b) Injury due to the ingestion of liquid mustard in food or water may require morphine and atropine for relief of pain, and shock therapy for collapse.

(4) *Prognosis:*

(a) With ordinary field exposures of mustard vapor, it is not anticipated that deaths will occur from the systemic effects of the absorbed mustard. Such deaths may occur from prolonged exposures to high concentrations of vapor, or in instances of extensive liquid contamination of the skin in which decontamination is neglected or unduly delayed. The occurrence of shock or pronounced leucopenia in such cases may be regarded as bad prognostic signs.

(b) Severe injury from ingestion of mustard is rare.

10. NITROGEN MUSTARDS (HN)

A. General

The nitrogen mustards are oily, colorless, or pale yellow liquids, sparingly soluble in water but freely soluble in organic solvents. Some possess a faint fishy odor, while others are odorless. Their volatility varies with the particular compound. All are persistent, though not equally so. They are less readily hydrolyzed than mustard or lewisite. All their hydrolytic products, except the final ones, are toxic.

B. Eyes

(1) *Symptoms and pathology:* Nitrogen mustards irritate the eye in doses which do not significantly damage the skin or respiratory tract. The irritation (caused by the nitrogen mustards) appears in a shorter time than that from mustard but not so early as that from lewisite. Mild or moderate exposure causes mild smarting and lacrimation within 20 minutes. Thereafter, symptoms may wax and wane until they become persistent about 2½ hours later and reach their maximum in 8 to 10 hours. After more severe exposure, symptoms may begin immediately and progress for 24 hours or longer. Mild exposure produces erythema and edema of the palpebral and bulbar conjunctivae and superficial steamy haziness of the cornea. Irritation, lacrimation, deep eye pain, miosis, and photophobia are usually present. After more severe exposure the symptoms described above are followed by spotty hemorrhagic discolorations of the iris,

The corneal epithelium begins to show a roughened, lusterless surface, with areas of punctate staining demonstrable by the instillation of fluorescein. Severe exposure may cause the corneal epithelium to exfoliate. Slit lamp examination will reveal clouding and edema of the corneal substance extending deep below Bowman's membrane. Local necrosis of the cornea may rupture the globe.

(2) *Decontamination and treatment:* These are the same as for mustard. (See par. 9B, p. 10.) In general the symptoms and lesions are more severe, requiring intensive and early treatment with atropine.

(3) *Prognosis:* The prognosis in contamination with any liquid nitrogen mustard is serious, unless the agent is removed by immediate decontamination. Mild injury progresses to complete recovery in about 2 weeks. Severe injury heals more slowly, requiring 9 to 12 weeks or longer. The cornea heals by vascularization, and the iris with discoloration and atrophy. Scarring may be expected.

C. Skin

(1) *Symptoms and pathology:* In mild exposures there may be no skin lesions. After severe exposure erythema may appear earlier than in mustard contamination. There may be irritation and itching as with mustard. Later, blisters may appear in the erythematous areas. Liquid nitrogen mustards are also vesicant. The skin lesions are similar to those caused by mustard.

(2) *Decontamination and treatment:* The absorption of liquid nitrogen mustards through the skin is slower and more complete than that of mustard. Therefore, for the prevention of systemic toxicity, decontamination should be carried out as late as 2 to 3 hours after exposure, even at the expense of increasing somewhat the severity of the local reaction. Early decontamination procedures are the same as for mustard. (See par. 9D, p. 15.) If early decontamination has been neglected late decontamination should be performed even if erythema is already present and there is no evidence of liquid nitrogen mustard on the skin. Protective ointment, S-461 or S-330 should be liberally applied, thoroughly rubbed into the affected area for about 1 minute and wiped off as completely as possible. Further cleansing may then be performed with soap and water.

(3) *Prognosis:* Most blistered areas will heal in 2 to 4 weeks if infection is prevented. Occasionally, deeper burns require a longer time.

D. Respiratory Tract

(1) *Pathology:* The lesions caused by nitrogen mustards are similar to those caused by mustard. They decrease in severity down the respiratory tract from the point of entry. In the nose, larynx,

and trachea there may be swelling, erythema, and necrosis of the mucosa, followed by sloughing, and fibrinous exudation. Laryngeal edema and necrosis may lead to respiratory obstruction. In severe cases the damage may extend to the bronchioles and alveoli. Although pulmonary edema usually is not massive, secondary pulmonary infection is common.

(2) *Symptoms:* The symptoms are much the same as those due to mustard, namely, delay in appearance, irritation of the nose and throat, hoarseness progressing to aphonia, and a persistent cough. Fever, dyspnea, and moist rales may develop. Bronchopneumonia may appear after the first 24 hours.

(3) *Treatment:* The treatment of casualties with respiratory tract involvement is the same as for mustard. (See par. 9F(3), p. 17.)

(4) *Prognosis:* Mild tracheitis is likely to result in a persistent cough. Low grade fever may persist a week or longer. The prognosis is grave if there is a severe respiratory tract involvement. Most late deaths are due to pneumonia.

E. Gastro-intestinal Tract

Following oral administration or systemic absorption, the nitrogen mustards cause injury to the intestinal tract. In animals severe diarrhea, which may be hemorrhagic, occurs. Lesions are most marked in the small intestine and consist of degenerative changes and necrosis in the mucosa. In man, the ingestion of 2 to 6 milligrams causes nausea and vomiting.

F. Systemic Effects

(1) *Pathology:* The most specific effects of the nitrogen mustards are on the hematopoietic and lymphoid tissue. These follow absorption from the intact skin, respiratory, or gastro-intestinal tracts. In bone marrow the degenerative changes can be detected within 12 hours and may progress to severe aplasia. The thymus, spleen, and lymph nodes involute rapidly with necrosis and phagocytosis of their lymphocytes. This injury is demonstrable in the blood through a transient leucocytosis of a few hours' duration, followed by severe lymphopenia, granulocytopenia, thrombocytopenia, and a moderate anemia. The blood picture may show little change other than lymphopenia for 5 to 10 days after exposure, at which time the white count may fall to 500 cells/mm^3, or lower. The various nitrogen mustards differ in their abilities to produce these changes.

(2) *Treatment:* The blood should be studied carefully and transfusions of whole blood given for thrombocytopenia or anemia. Vomiting or severe diarrhea may call for the replacement of fluid and electrolytes in addition to symptomatic treatment with sedatives, atropine, and opiates. If these symptoms are prolonged, every attempt

should be made to maintain an adequate nutritional status by the intravenous route if necessary.

(3) *Prognosis:* Severe leucopenia, thrombocytopenia and a loss in weight are grave manifestations.

(4) *Diagnosis:* Diagnosis is based upon a history of exposure, a faint fishy odor on the skin and clothing, and the signs and symptoms described above.

11. LEWISITE (L)

A. General

(1) Lewisite is an oily, colorless to light amber liquid, with a faint odor of geraniums. It is more volatile and less persistent than mustard. Lewisite is readily soluble in gasoline, kerosene, and alcohol. Although poorly soluble in water, it is rapidly hydrolyzed in contact with moisture. Lewisite oxide, one of the hydrolysis products, is vesicant and toxic and may contaminate ground for long periods. Lewisite, like mustard, penetrates fabrics and rubber, making it dangerous to wear clothing or rubber gloves previously contaminated.

(2) Lewisite, like mustard, injures the eyes, skin, and respiratory tract but the systemic effects are more likely to be serious than those following mustard contaminations. In contrast to liquid mustard, lewisite causes stinging pain in 10 to 30 seconds which increases in severity. Burns from field concentrations of vapor are unlikely and no decontamination or treatment is necessary following exposure unless pain is experienced. In such a case the procedures to be followed are those described under liquid lewisite.

B. Eye

(1) *Symptoms, pathology and prognosis:* Liquid lewisite alone causes severe damage to the eye. On contact, pain and blepharospasm occur instantly. Edema of the conjunctiva and lids follows rapidly and closes the eye in an hour. Inflammation of the iris usually is evident by this time. After a few hours the edema of the lids begins to subside, while haziness of the cornea develops and iritis increases. The corneal injury, which varies with the severity of the exposure, may heal without residual, may develop pannus formation, or progress to massive necrosis. The iritis may subside without permanent impairment of vision, if the exposure was mild, or after heavy exposure hypopyon may ensue, terminating in necrosis, depigmentation of the iris, and synechia formation. Liquid lewisite instantaneously produces a gray searing of the cornea like an acid burn at the point of contact. Necrosis and sloughing of both bulbar and palpebral conjunctivae may follow very heavy exposure. All injured eyes are

susceptible to secondary infection. Mild lewisite conjunctivitis in man heals in a few days without specific treatment. Severe exposures may cause permanent injury or blindness.

(2) *Decontamination of eyes:*

(a) *Liquid:* Eyes contaminated with liquid lewisite are decontaminated by the same procedure as those contaminated with liquid mustard. (See par. 9B(2), p. 10.) *Immediate decontamination is essential.* When liquid lewisite is the contaminating agent the immediate pain and blepharospasm caused by the agent is rapidly relieved by the instillation of BAL ointment.

(b) *Effectiveness of BAL:* BAL is effective against lewisite for a longer period of time after contamination than it is against mustard. If BAL is used within the first minute following contamination, the eye usually recovers in a few days. When used 10 minutes after contamination the eye requires several weeks to heal and usually suffers permanent damage. After 30 minutes BAL has practically no effect. BAL ointment is available to all men. It is issued in a half-ounce tube and is to be carried in the gas mask carrier. Hydrogen peroxide solutions must not be used in the eye; they are worthless for the treatment of lewisite injury and are damaging to the cornea.

(c) *The Treatment of lewisite conjunctivitis:* The treatment is like that described for mustard. (See par. 9B(8), p. 12.)

C. Skin

(1) *Symptoms:* Stinging is felt in 10 to 30 seconds after contact with liquid lewisite. This increases in severity as the lewisite penetrates and in a few minutes becomes a deep aching pain. Pain on contact with liquid lewisite usually gives sufficient warning so that decontamination may be begun promptly and deep burns will therefore rarely occur in conscious victims. After about 5 minutes contact, a gray area of dead epithelium is noted which resembles that seen in corrosive burns. Erythema and edema of the skin appear in about 30 minutes. The erythema is like that caused by mustard but is accompanied by more pain. Itching and irritation persist only about 24 hours whether or not a blister develops. Blisters are often well developed in 12 hours and are painful at first, in contrast to the relatively painless mustard blister. After 48 to 72 hours the pain lessens.

(2) *Pathology:* Liquid lewisite produces more severe lesions of the skin than does liquid mustard. Contamination of the skin with liquid lewisite is followed after a short time by erythema. Vesication follows, and tends to cover the entire area of erythema, so that the surrounding halo of erythema is less conspicuous than with mustard blisters, although the two are often indistinguishable. Microscopically, the lewisite blister roof is slightly thicker than the mustard blister roof, consisting of almost the complete thickness of the epidermis which shows more complete coagulation necrosis and less disintegrative necrosis than that of the mustard blister. The yellowish blister fluid is slightly more opaque than that of the mustard blister, and microscopically, contains a greater number of

inflammatory cells. It contains a trace of arsenic on analysis, but is non-toxic and non-vesicant. Within the corium and subcutaneous tissue, there is deeper injury to the connective tissue and muscle, greater vascular damage, and more severe inflammatory reaction than is exhibited in mustard burns. In large, deep, lewisite burns, there may be considerable necrosis of tissue, gangrene and slough.

(3) *Prognosis:* Lewisite erythema usually recedes more rapidly than mustard erythema and with less pigmentation. Small lewisite blisters heal in about the same time as those due to mustard. Larger lewisite lesions may involve deep injuries which heal slowly and require skin grafts. Sensitization to lewisite after repeated burns occurs as with mustard.

(4) *Decontamination of skin:*

(a) Vapor. The risk of skin burns from field concentrations of lewisite vapor is small and decontamination of the skin for such exposure should seldom be required. When drops of liquid lewisite contaminate the clothing, concentrated vapor from these drops penetrates the cloth and damages the underlying skin. Such clothing must be removed promptly. Decontamination of skin may be accomplished if specific measures are taken within a few minutes after contact. (See pars. (2), (3), and (4) below.)

(b) *Decontamination of the skin. Liquid:* (1) The removal of liquid lewisite from the skin is the individual responsibility, that is, a matter of self-aid for all personnel in all branches.

(2) If the skin is wet with lewisite, the excess liquid is quickly removed by blotting with absorbent material.

(3) For each blot a clean portion of the absorbent should be used and then discarded. Care should be taken in discarding the used absorbent to prevent spread of lewisite to personnel or material.

(4) BAL ointment is then immediately applied to area contaminated. BAL is a specific antidote for lewisite and other arsenicals. It should be spread on the skin in a thin film, rubbed in with the fingers and allowed to remain at least 5 minutes and reapplied. Thereafter, the ointment may be washed off when conditions permit. The strong "rotten-egg" odor of BAL preparations must be considered in close night fighting.

(5) If BAL ointment is not available, wash immediately with soap and water.

(6) Organic solvents are effective in preventing blisters only when used in the first few seconds. Care must be taken and avoid spreading the solution of the agent to adjacent areas.

(7) BAL ointment sometimes causes temporary stinging and itching urticarial wheals on the skin. The lesions usually last only an hour or so and should not cause alarm. Mild dermatitis, persisting a few days, may follow a single application. Dermatitis is fairly frequent if repeated applications are made to the same skin area. This prevents the use of the BAL ointment as a protective film in contrast to the use of anti-mustard protective ointments.

(8) Wounded men, contaminated with liquid lewisite, will seldom be received at battle dressing stations on ships or medical installations ashore in time to prevent blistering. However, their burns may be lessened and significant systemic protection obtained if the decontamination procedures outlined under sec. XVII are carried out promptly.

(c) *Decontamination of hair:* Contaminated hair may be clipped off or decontaminated with BAL ointment and then washed with soap and water.

(d) *Treatment of lewisite erythema:* The treatment of lewisite erythema is the same as that for mustard erythema, except that treatment seldom is required for longer than 24 hours. BAL ointment may be tried in the early stages.

(e) *Treatment of lewisite blister:* Lewisite and mustard blisters are treated alike. (See par. 9C(5), p. 14.)

(f) *Treatment of denuded areas and infected lewisite burns:* The treatment of these lesions is the same as that for similar lesions due to mustard. (See pars. 9C(6) and (7), pp. 14 and 15.)

(g) *Treatment of deep lewisite burns:* Large burns may be accompanied by serious systemic poisoning and shock demanding general measures as well as local treatment. Morphine and splinting of the affected parts may be necessary for the relief of pain. When the burned tissue becomes gangrenous, it should be treated in accordance with sec. XII as for thermal burns.

D. Respiratory Tract

(1) *Symptoms:* Lewisite vapor is highly irritating to the respiratory tract and quickly induces sneezing and coughing. This properly together with the strong odor of geraniums so effectively warns of the presence of the gas that no severe respiratory injuries are likely to occur. Inhaled lewisite vapor produces lesions of the respiratory mucosa essentially similar to those produced by mustard. Edema of the lung often is more marked, and is frequently accompanied by pleural fluid.

(2) *Treatment of respiratory tract injury due to lewisite:* Since there have been no human respiratory tract injuries from lewisite, treatment is recommended solely from the results of animal experimentation. In general, the treatment is a combination of that for the systemic effects of lewisite plus that for mustard respiratory tract injuries. (See par. 9F(3), p. 17.)

(3) *Prognosis:* The prognosis in respiratory tract injuries from lewisite is unknown but probably is similar to that for an equivalent mustard injury, with the added danger of systemic arsenical poisoning unless treatment with BAL preparations is instituted.

E. Systemic

(1) *General:*

(a) Lewisite and other arsenical blister gases in liquid form can readily penetrate the human skin and may lead to dangerous systemic poisoning. The severity of the toxic effects is roughly proportional to the amount of the arsenical absorbed per pound of body weight. The amount of arsenical absorbed through the skin from exposure to field concentrations of the vapor of the arsenical agents is too small to cause systemic poisoning. The greater and more extensive the skin contamination with liquid arsenical blister gases and the longer the period of contact before decontamination, the greater will be the amount of arsenical blister gas absorbed. The fatal doses of the arsenical blister gases for man are not known, but 1 to 2 cc. of liquid lewisite absorbed

through the skin is believed to be sufficient to produce a serious or fatal result. Half this amount may cause alarming symptoms and a protracted illness. A manifestation of this systemic poisoning is a change in capillary permeability which permits the loss of sufficient fluid from the blood stream to cause hemoconcentration, shock and death. In nonfatal cases, hemolysis of erythrocytes may occur with resultant hemolytic anemia.

(b) Although lewisite is oxidized within the body, the oxidation product may still be toxic. Its excretion into bile by the liver produces focal necrosis of that organ, necrosis of the mucosa of the biliary passages with peribiliary hemorrhages, and some injury to the intestinal mucosa. Acute systemic poisoning from large burns in animals causes pulmonary edema, diarrhea, restlessness, weakness, sub-normal temperature, and low blood pressure.

(2) *Personal decontamination:* It is important that all liquid arsenical gas be removed from the skin by the injured man himself, by personal decontamination with BAL ointment at the earliest possible moment. If this is done with sufficient promptness to prevent immediate signs of skin damage (a gray or dead white appearance of the outer skin layers) or to prevent the appearance of erythema during the 30 minutes following decontamination, there is little likelihood that a toxic dose of the arsenical will be absorbed.

(3) *Indications for systemic treatment with BAL:*

(a) Cough with dyspnea and frothy sputum, which may be blood tinged, and other signs of pulmonary edema. These are manifestations of early damage to the lung capillary bed caused either by the absorption through the skin of large amounts of the arsenical blister gases or by the inhalation of dangerous amounts of their vapors. Regardless of the portal of entry, serious respiratory damage requires prompt systemic treatment with BAL.

(b) A skin burn the size of the palm of the hand or larger, caused by a liquid arsenical blister gas, which was not decontaminated within the first 15 minutes: prompt treatment with BAL ointment locally and BAL in oil by injection for systemic poisoning is indicated.

(c) A large skin contamination covering 5 percent (about 1 square foot) or more of the body surface, caused by a liquid arsenical vesicant, provided there is evidence of immediate skin damage (gray or dead white blanching of skin) or erythema, develops over the area within 30 minutes. Such extensive contamination may result in dangerous absorption through the skin within 15 minutes even though decontamination has been accomplished within these 15 minutes. Treatment for systemic poisoning with BAL is therefore indicated.

(d) Cases which have been seen late, where there are blisters the size of the palm of the hand or larger.

(4) *Treatment of systemic poisoning with BAL:* Two types of treatment are required: First, neutralization of the absorbed arsenical by the intramuscular injection of 10 percent BAL in oil; and second neutralization of the deposit of liquid arsenical on and within the skin at the site of contamination by the local application of BAL ointment. For the BAL treatment of direct injury to the respiratory tract caused by the inhalation of vapor, only the intramuscular injection of BAL in oil is used.

(5) *Reactions caused by BAL in oil:* The signs and symptoms may include a feeling of constriction in the throat, a sense of oppres-

sion in the chest, a burning sensation of the lips, mild lacrimation, slight reddening of the eyes, dryness of the mouth, tenderness and increased muscle tonus at the site of injection, mild restlessness and nervousness accompanied by sweating of the hands, apprehension on the part of some patients, and mild nausea and vomiting, on eating, in a few. There may be a transient rise in blood pressure. Slight tenderness at the site of injection may persist for several days. All reactions are generally transitory, beginning 15 to 30 minutes after injection and lasting approximately 30 minutes. Elevation of blood pressure or other reactions, unless unduly severe and prolonged, do not contraindicate the continued administration of the full course of 4 injections of the drug.

(6) *Dosage of BAL in oil:*

(a) An immediate intramuscular injection of 10 percent BAL in oil should be given deep into the muscles of the buttocks. Particular care should be exercised to avoid injecting the solution into a blood vessel. Dosage must be adjusted to the weight of the patient as follows:

Weight in pounds	*cc.*
125	2.5
150	3.0
175	3.5
200	4.0

(b) The intramuscular injection of 10 percent BAL in oil should be repeated at different sites in the same general area at 4, 8, and 12 hours after the initial injection, making a total of 4 intramuscular injections of equal dosage.

(c) If pulmonary symptoms or other evidence of severe arsenical poisoning are present, the interval between the first and second doses may be shortened to 2 hours. In severe cases, subsequent daily intramuscular half doses should be given at the rate of one injection per day for 3 to 4 days. These small doses should produce no symptoms.

(7) *Essentials for prevention and BAL treatment of systemic poisoning due to arsenical blister gases:*

(a) Prompt self-decontamination with BAL ointment.

(b) If any of the indications for systemic treatment exist, as outlined in par. 3, the local skin burn should be treated promptly with a liberal inunction of BAL, and left covered with a layer of the ointment.

(c) An immediate intramuscular injection of an appropriate dose of 10 percent BAL in oil followed by further injections at proper intervals.

(8) *Material:* The material is put up in a 10 percent solution in peanut oil, containing 20 percent benzyl benzoate as a solvent. It has been added to the *Medical Supply Catalog* as: Stock No. S1-110 BAL in Oil, 10 percent, 5-cc., ampul, 10 ampules in box, unit—box. It may be obtained on requisition, NavMed 4, from the Naval Medical Supply Depot, Brooklyn, N. Y.; Naval Medical Supply Depot, Oakland, Calif.; or Naval Medical Supply Depot, Navy 128. Original distribution should be to activities in the forward areas and on the basis of 4 units (40 ampules) per 1,000 men. Requisitions should be submitted

to the nearest naval medical supply depot listed above and material will be furnished at the earliest possible date.

Caution: The point that the use of BAL in oil does not preclude the necessity for self-decontamination should be emphasized.

12. ETHLYDICHLORARSINE (ED)

A. Properties

Ethyldichlorarsine is a colorless or brown liquid which is more volatile than lewisite and possesses a faint fruit odor.

B. Pathology

The lesions are the same as those caused by lewisite. (See pars. 11B and 11C, pp. 21 and 22.)

C. Symptoms

Low concentrations of vapor produce no symptoms for the first minute even though the gas mask is put on at once. Stinging pain in the nose, a burning sensation in the throat, headache, nausea and vomiting occur. Symptoms may increase for several minutes before they regress. High concentrations are instantly so irritating to the eyes and respiratory tract that they compel wearing of the gas mask. A stinging and burning sensation is felt on the skin within 1 or 2 minutes. In very hot weather this may progress to redness in 10 minutes, and to shallow blistering in a few hours. Pain persists only about 24 hours, and the blisters crust over in a few days and heal rapidly. Liquid ethyldichlorarsine, like lewisite, is immediately painful on the skin and causes severe blistering. It produces eye injuries similar to, but less severe than those due to lewisite.

D. Diagnosis

The following factors should be considered in making the diagnosis:

(1) History of exposure.

(2) Fruity odor of skin and clothing.

(3) Intense sternutatory irritant, and early vesicant effect.

E. Decontamination

Decontaminating procedures are identical with those for lewisite. (See pars. 11B and 11C, pp. 21 and 22.)

F. Treatment

Treatment of mild respiratory tract irritation is the same as that for DM. (See par. 17D, p. 32.) After decontamination, eye and skin lesions are treated as those due to mustard. BAL preparations may be used if indicated as prescribed for lewisite. (See pars. 11B(2), 11C(4), and 11E(4), pp. 22, 23 and 25.)

G. Prognosis

Respiratory tract irritation from low vapor concentrations subsides within an hour. Skin burns in general, heal more rapidly than similar mustard burns. Liquid ethyldichlorarsine contamination in the eye causes serious injury, possibly blindness, unless Ointment BAL is promptly administered. (See par. 11B(2), p. 22.)

13. PHENYLDICHLORARSINE (PD)

A. Properties

This agent, a clear viscid liquid, is less volatile than lewisite or ethyldichlorarsine. It is readily hydrolyzed in water.

B. Action

Phenyldichlorarsine, when inhaled, is a strong sternutator and lung irritant. Eye injury produced is similar to that caused by lewisite. (See par. 11B(1), p. 21.) On the skin the vapor or liquid is only slightly less vesicant than mustard or lewisite. If absorbed, phenyldichlorarsine may produce systemic poisoning.

C. Pathology

The lesions and the systemic effects produced by phenyldichlorarsine are essentially those of lewisite.

D. Symptoms

Irritation of the eyes, nose, and throat is prominent. Symptoms referable to the lungs and skin are like those produced by lewisite. (See pars. 11C(1) and 11D(1), pp. 22 and 24.)

E. Treatment

Treatment in general is the same as that described for lewisite. (See pars. 9B(8), 9C(5), 11D(2) and 11E(4), pp. 12, 14, 24 and 25.)

14. MIXED BLISTER GASES

A. General

Arsenical vesicants, such as lewisite (L) or phenyldichlorarsine (PD) may be encountered when mixed with mustard. Such mixtures do not produce more severe lesions than either agent alone, but they tend to confuse and make diagnosis difficult.

(1) An individual at the time of the gas attack whether by airplane spray, shell or bomb burst, may be unable to ascertain the exact nature of the agent. The hazard of encountering liquid lewisite *alone* appears small as liquid lewisite due to its properties and action, is not likely to be used by the enemy other than as a mixture with other blister gases. In view of this situation, the individual shall carry out the

following procedure when contaminated with *any liquid blister gas* unless directed otherwise by the local command.

B. Decontamination

(1) *Eyes:*

Eyes contaminated by a mixture of liquid blister gases are treated in the same fashion as in the case of mustard. (See par. 9B(2), p. 10.) The arsenical vesicant portion of the agent will produce pain and blepharospasm which will probably necessitate working the ointment between the lids, as for lewisite, before the individual is able to open his eyes.

(2) *Skin:*

(a) The free liquid blister gas is blotted from the skin with the absorbent cloth wrapped around each tube of S-330, protective ointment, or by using any absorbent material at hand. *Discard the used absorbent.* Protective ointment, S-330 is then applied freely to the area and thoroughly rubbed into the affected areas with the fingers for about 15 seconds. The excess is immediately removed. In the case of large splashes, the ointment shall be applied and removed once more.

(b) The BAL ointment is then spread on the skin in a thin film, rubbed in with the fingers, allowed to remain at least 5 minutes, and reapplied. BAL ointment sometimes causes temporary stinging and itching urticarial wheals when applied to the skin. These lesions usually last only an hour or so and should not cause alarm. Mild dermatitis is fairly frequent if repeated applications are made to the same skin area. This prevents the use of BAL as a protective film.

(c) The decontaminated skin area should be thoroughly washed with soap and water as soon as practicable following decontamination if such facilities are available.

(d) The individual must familiarize himself with the two ointments. He should know that the large 3-ounce tube contains protective ointment S-330 and the smaller 1½-ounce tube BAL ointment.

C. Treatment

(1) *Eyes:* Definite treatment of eye injuries due to mixtures is like that for mustard injury of the eye. (See pars. 9B(8) and 9B(9), pp. 12 and 13.)

(2) *Skin:* Definitive treatment of skin lesions produced by mixtures is like that described for lewisite and mustard burns. (See pars. 9C, 9E, 9F and 9G, pp. 13, 16 and 17.)

D. Supply Catalog Listing

Subject ointments are listed in the Medical Supply Catalog as follows:

S1-3361 Ointment, BAL, ½-ounce tube.
S1-3375 Ointment, Protective, S-461 and S-330, 3-ounce tube each.

(1) One tube of BAL ointment and one of protective ointment, preferably S-330, shall be provided with each gas mask. Nonmedical activities issuing gas masks shall request these items from the nearest medical supply depot or storehouse. Initial allowance for advance base personnel will be included in the J15 A and B Components. It will be noted that BAL ointment is used on the skin and in the eye.

(2) In accordance with the policy to replace gradually all issues of Ointment, Protective, Stock No. S1-3375, formula S-461, by the formula, S-330, all advanced and forward areas, assault troops and combat forces shall replace S-461 with S-330 as fast as the material becomes available in the areas. Activities in temperate and arctic climates and in rear areas where the possibility of gas attack is remote will replace stocks of S-461 with S-330 when stock is available to meet all requirements. Formula S-461 for which replacement has been made by S-330 should be retained and held as a strategic reserve.

SECTION IV

LACRIMATORS

15. CHLORACETOPHENONE (CN), CHLORACETOPHENONE SOLUTION (CNS), CHLORACETOPHENONE TRAINING SOLUTION (CNB) AND BROMBENZYL CYANIDE (BBC).

A. General Symptoms

General symptoms produced by the lacrimators include lacrimation, photophobia, blepharospasm and some irritation of the nose and of the freshly shaven face. In hot weather moist skin will be irritated. In addition, chloracetophenone solutions CNS and CNB may cause some mild papulovesicular dermatitis, especially in warm weather, and occasional vomiting. Lacrimator casualties ordinarily do not require medical attention.

B. Self-aid and Treatment

(1) *Self-aid:* The mask should be put on and rapid breathing maintained to aid circulation of air in the mask. The eyes are kept open as much as possible. They should not be rubbed. If a liquid or solid agent has entered the eye, it should be promptly washed out with water from the canteen.

(2) *Treatment:*

(a) *Eyes:* Lacrimators produce a marked but self-limited irritation of the conjunctiva. When liquid lacrimators are splashed into the eye, the action is corrosive and resembles the burns of a strong acid. The eye should be flushed immediately with water from the canteen. This may be followed by the installation into the eye of a solution of sodium sulfite (¼ percent), if available, which dissolves and neutralizes the irritating agent. Eye pain may be treated by instilling butyn ophthalmic ointment or eye drops on anesthetic solution. The further treatment is as for other burns of the eye. Local anaesthesia should not be used unless necessary and then not oftener than once every 6 hours.

(b) *Skin:* Superficial skin burns may be treated by calamine lotion for symptomatic relief. Deep burns should be treated as other skin burns.

VOMITING GASES (NOSE GASES, IRRITANT SMOKES, STERNUTATORS)

16. DIPHENYLAMINECHLORARSINE (DM, ADAMSITE), DIPHENYLCHLORARSINE (DA) AND DIPHENYLCYANARSINE (DC).

General: These agents are crystalline solids which are dispersed by heat as fine particulate smokes. DM smoke is canary yellow near the point of emission, while those of DA and DC are white; all are colorless when diluted with air. Low concentrations are effective and smell like burning fireworks.

These agents produce strong pepperlike irritation in the respiratory tract, most pronounced in the trachea and large bronchi. The onset of symptoms may be delayed for several minutes, especially with DM, and effective exposure therefore may occur before the presence of the smoke is suspected. If the gas mask is then put on, symptoms will increase for several minutes, in spite of adequate protection. The individual may believe his mask is ineffective, remove it, and be further exposed. This is disastrous if the smoke is immediately followed by a lethal gas.

The gas mask offers adequate protection against these agents.

17. DIPHENYLAMINECHLORARSINE (DM) (ADAMSITE)

A. Pathology

DM produces local inflammation of the nose, nasal accessory sinuses, throat and eyes.

B. Symptoms

These consist of pain and a sense of fullness in the nose and sinuses, accompanied by a severe headache, intense burning in the throat, and tightness and pain in the chest. Irritation of the eyes and lacrimation are produced. Coughing is uncontrollable and sneezing is violent and persistent. The nasal secretion is greatly increased and quantities of ropy saliva flow from the mouth. Nausea and vomiting are prominent. Mental depression may occur.

C. Diagnosis

This is made from the history of exposure and the relatively rapid spontaneous improvement which occurs despite the original miserable appearance and condition of the individual.

D. Treatment

The mask must be worn in spite of nausea and salivation, but it should be lifted from the face during actual vomiting. Frequent inhalations of chloroform administered early, give relief. Aspirin may be given to relieve the headache and general discomfort. Few cases should reach the medical service for treatment, since recovery is prompt and the personnel can carry out their battle mission in spite of sternutators.

E. Prognosis

Ordinarily all symptoms disappear in about 1 to 2 hours. Permanent injury is unlikely following exposure to field concentrations. Exposure in confined spaces may produce pulmonary injury and death.

18. DIPHENYLCHLORARSINE (DA), DIPHENYLCYANARSINE (DC)

The pathology, symptoms, diagnosis, treatment, and prognosis are similar to those of diphenylaminechlorarsine (DM).

Section VI

SCREENING SMOKES

19. GENERAL

The most important of these agents are HC mixture (HC), sulfur trioxide-chlorsulfonic acid (FS), and titanium tetrachloride (FM). These smokes are not toxic in field concentrations, but may be dangerous in the heavy concentrations formed at the site of dispersion or within closed spaces where accidental discharge might occur.

20. WHITE PHOSPHORUS (WP)

See par. 27, p. 35.

21. TITANIUM TETRACHLORIDE (FM)

A. Pathology

The liquid produces acid burns.

B. Symptoms

Smoke generated by liquid FM is unpleasant to breathe as it irritates the nose and throat, but it is not dangerous in field concentra-

tions. Exposure of the eyes to spray will cause conjunctivitis, with lacrimation and photophobia. Skin burns like those from acids are produced by contact with the liquid.

C. Treatment

The burned eyes or skin should be thoroughly washed with water and then treated like any other burn.

(1) From laboratory experiments it has been found that concentrations of FM smoke which can be tolerated by man are non-toxic. Gas masks shall only be worn in FM smoke when marked irritation is noted.

D. Prognosis

Good.

22. SULFUR TRIOXIDE-CHLORSULFONIC ACID SOLUTION (FS)

A. Pathology

Acid burns are produced by contact with the liquid.

B. Symptoms

These are usually limited to a prickling sensation of the skin, but exposure to heavy concentrations may result in severe irritation of the eyes, skin, and respiratory tract.

C. Treatment

The eye is irrigated with water at once. Flurorescein will reveal corneal ulceration. For pain, butyn ophthalmic ointment or eye drops of anaesthetic solution may be instilled. The eye is then covered with a light pad. Skin burns should be washed with water and then with sodium bicarbonate solution. Later treatment should be that employed for other burns. The irritant qualities of this smoke will require masking before toxic concentrations are encountered. The standard Navy gas mask will afford adequate protection.

D. Prognosis

The prognosis depends on the degree of corneal ulceration. The prognosis of skin burns and respiratory irritation is good.

23. HC MIXTURE (HC)

A. Toxicity

Field concentrations of this smoke are harmless, but dangerous to fatal levels, may be encountered in poorly ventilated spaces or near the point of smoke production.

B. Pathology

HC smoke, if inhaled, damages the respiratory tract by the action of the contained zinc chloride. Following severe exposure a chemical pneumonia with pulmonary edema may develop as in phosgene poisoning.

C. Symptoms

When HC is breathed in high concentrations there is a feeling of suffocation and some irritation of the nose and throat with coughing and choking. This may be followed by bronchial constriction with symptoms similar to those of asthma, severe exposures produce nausea and vomiting. Later, signs and symptoms of pulmonary edema may appear.

(1) A number of fatalities have occurred following exposure to heavy concentrations of this smoke in the field. During exposure to such concentrations irritation of the eyes, choking, and cough are common symptoms. The standard Navy gas mask will afford adequate protection. Eighty-five percent of unmasked naval personnel aboard a vessel exposed to a heavy screen for 90 minutes showed an elevation of temperature. There was moderate injection of the conjunctivae and pharynx, pain in the chest on deep inspiration, headache, slight cough, malaise and muscular pains. Prolonged exposures may lead to serious respiratory difficulties and death.

D. Treatment

(1) All personnel who have the initial symptoms of cough, rhinitis and lacrimation should wear the standard Navy gas mask and if symptoms increase report to the medical officer.

(2) The early symptoms due to bronchial constriction may be relieved by the intramuscular injection of 0.5 mg. (0.5 cc. of a 1:1,000 solution) of epinephrine hydrochloride. This dose may be repeated in 20 to 30 minutes if necessary. If the exposure has been heavy, treatment with intramuscular BAL in oil should be instituted. The dose and procedure are the same as for systemic lewisite poisoning (See par. 11E(4), p. 25), except that injections are continued for 48 hours at 4-hour intervals. Should pulmonary edema develop, treatment is like that for phosgene poisoning. (See par. 5D, p. 5.)

E. Prognosis

The prognosis depends on the severity of exposure and the extent of pulmonary damage.

INCENDIARY AGENTS

24. GENERAL

The principal agents in this group are thermite (TH), magnesium and its alloys, white phosphorus (WP), and combustible oils. All generate tremendous heat and can inflict severe burns. Chemical fire extinguishers containing carbon tetrachloride (pyrene) or liberating carbon dioxide should not be used in confined spaces to extinguish thermite and magnesium incendiary bombs. When carbon tetrachloride comes in contact with flame or a highly heated metal, a mixture of phosgene, chlorine, carbon monoxide, and hydrochloric acid is liberated. *The service mask does not offer protection against carbon monoxide.*

25. THERMITE (TH)

Thermite incendiaries burn at a temperature of about 4,330° F. and scatter molten iron. Frequently explosive charges are added and make control hazardous. The particles of iron that lodge in the skin usually produce multiple small but deep burns. The particles should be cooled immediately with water and removed. Thereafter the treatment is that used for other thermal burns.

26. MAGNESIUM AND ITS ALLOYS

Magnesium burns at a temperature of about 3,630° F. with a scattering effect similar to that of thermite. Deep burns are caused by its particles, which, unless removed promptly, result in slow healing. Removal is usually possible under local anesthesia. When explosive charges have been added to a magnesium bomb, the fragments may be embedded deep in the tissues, causing the localized formation of hydrogen gas and tissue necrosis.

27. WHITE PHOSPHORUS (WP)

A. General

Extensive burns (See fig. 1.), may be produced by incandescent particles of white phosphorus. The burns are usually multiple, deep, and variable in size. The smoke is non-toxic in field concentrations. White phosphorus continues to burn unless deprived of oxygen.

B. Copper Sulfate Pads

Three copper sulfate pads (stock No. S2-1373) issued in individual units are available. These terry towel pads contain approximately 1 gram of copper sulfate. The following self-aid procedure is required:

(1) Douse burn with canteen water.

(2) Wet pad with canteen water.

(3) Press wet pad directly onto the white phosphorus particle then squeeze liquid from pad onto burned area.

(4) Carefully pick out copper sulfate coated particles of white phosphorus from the skin with a knife, bayonet, match stick or the pad itself.

(5) Discard the pad.

(6) Do not use the pad as a dressing for the burn after the phosphorus is removed.

C. Wet Dressing

If the copper sulfate pads are not available the burned areas should be immersed immediately in water or covered with dressings soaked in water, urine or any nonirritant aqueous solution. Immersion should be continued until a 5 percent solution of copper sulfate is

Figure 1. CASUALTY

The subject of this photograph was involved in an accident while filling a white phosphorus shell and became a casualty for 3 months. The photograph was taken 24 hours following the injury.

The forefinger of the right hand was lost. The burns involved both hands anteriorly and posteriorly. The lesions were multiple and deep. Immediately following the accident the hands were immersed in a solution of 5 percent copper sulfate. After the coating of the phosphorus particle, the latter was removed and the wound debrided. The lesion was then treated as a thermal burn.

applied as a wet dressing. This copper sulfate wet dressing should be removed and shall not be used as a dressing for the burn as the copper sulfate will be absorbed and produce systemic toxicity. One case of copper sulfate poisoning has been reported due to the use of copper sulfate dressings for 90 minutes over a burn involving 10 percent of the body surface.

D. Remove Particles Under Water

Copper sulfate forms a noninflammable coating of black copper phosphide on the phosphorus particles. All particles should be removed under water unless the copper sulfate solution has been applied and may be located by their phosphorescence in the dark. Burning particles are recognizable by the evolution of smoke.

E. Debridement

The burn should be debrided promptly, if the patient's condition will permit, in order to remove bits of phosphorus which might be later absorbed and produce systemic poisoning. Following the removal of the particles the lesions are treated as thermal burns. An ointment with an oily base should not be applied until it is certain that all phosphorus has been removed.

28. OIL INCENDIARIES

A. General

Burns may be produced by flame throwers and by oil incendiary bombs which may also contain phosphorus and sodium. Lung damage from heat and irritating gases may be a complication added to the injuries from incendiaries, especially in confined spaces. Morphine should be given guardedly to patients with pulmonary complications. The treatment of burns caused by oil incendiaries is similar to that for other heat burns.

B. Flame Thrower Attack

(1) *General:* As flame from burning fuel fills an enclosed fortification the oxygen content of the air is reduced and hot fumes and smoke are produced. The coolest and least contaminated air is found at floor level.

(2) *Casualties:* Deaths may occur during or shortly after flame attack. Survivors may have thermal burns of the skin and upper respiratory tract as well as pulmonary damage from fumes. Laryngeal and glottic edema may cause suffocation.

(3) *Protection:* The floor level is the safest area during flame attack. Any kind of cover affords some protection from heat. A wool blanket is excellent. The gas mask shall be worn for the protection it affords against smoke and for its slight effect on the inspired air.

(4) *Treatment:* Casualties should be removed to fresh air as soon as possible. Artificial respiration (with the inhalation of 100 percent oxygen if possible) should be instituted if breathing has ceased. Burns of the skin are treated as any thermal burns. If there are burns about the face, the possibility of laryngeal burning with subsequent edema producing respiratory obstruction should be borne in mind so that tracheotomy can be performed in an emergency. The general treatment of the casualty burned by flame attack does not differ from the treatment of extensive thermal burns. (See sec. XII.) Plasma is given for the prevention of shock and other procedures outlined in sec. XII are followed.

Section VIII

SYSTEMIC POISONS

29. GENERAL

Systemic poisons produce their effects after absorption into the body. Hydrocyanic acid, cyanogen chloride and arsine are included in this group.

30. HYDROCYANIC ACID (AC)

A. Physical properties

Hydrocyanic acid is a colorless, highly volatile liquid which boils at 26° C. Its vapor is nonpersistent and has the odor of bitter almond.

B. Pathology

Hydrocyanic acid acts by combination with an enzyme essential for oxidative processes of the tissue. The central nervous system, particularly the respiratory center, is especially susceptible to this interference, and respiratory failure is the usual cause of death. In high concentrations of hydrocyanic acid (10 mg. per liter or more) the amount inhaled in a few breaths may be sufficient to cause immediate death without anatomical changes. After exposure to lower concentrations, death may be delayed for hours to days. Small areas of hemorrhage and softening may be found in the brain in fatal cases, and the more pronounced the longer the course.

C. Symptoms

The symptoms depend upon the concentration of the gas and the duration of the exposure. In high concentrations there is increased depth of respiration within a few seconds: violent convulsions after

20 to 30 seconds; cessation of regular respiration in 1 minute; occasional shallow gasps, and finally, cessation of heart action several minutes after initial exposure. Following moderate exposures, vertigo, nausea, and headache appear very early and are followed by coma and convulsions. These may persist for several hours or days and be followed by death or recovery. If the patient recovers after a prolonged course during which coma and convulsions were present, there may be evidence of damage to the central nervous system, such as irrationality, altered reflexes and unsteady gait, which may last weeks or longer. Mild exposure may produce headaches, vertigo, and nausea, but recovery is complete.

D. Diagnosis

The diagnosis may be made from the history, the odor, and the rapid onset of symptoms.

E. Treatment

(1) Adequate protection against field concentrations of AC is provided by all Navy gas masks with canister markings of B, BA, BB, B1, B2, and BX. Canisters marked A and those not marked are considered inadequate against AC and CK. These designations are embossed on one end of the canister; on canisters marked BA, BB and BX, the second letter is stamped in red ink. The most practicable therapeutic measure at present available is the inhalation of amyl nitrite. Amyl nitrite is a medical item carried in S2-1058 Kit, first-aid (gas casualties), 14-055 Field Medical No. 10, Case Nos. 1 and 2, Treatment of Chemical Casualties. When hydrocyanic acid is detected, the individual must attempt to hold his breath and adjust his gas mask. If he is capable of doing this, the hydrocyanic acid already absorbed will usually be detoxified. However, if the individual is incapacitated (disorientation, coma, or convulsions) emergency treatment must be given immediately by the nearest individual. If hydrocyanic acid is still present in the atmosphere and the stricken person has not been able to put on his gas mask, this must be done for him. He should be placed on the ground in a horizontal position. Two ampules of amyl nitrite are crushed and inserted under the facepiece. Since the patient may not be breathing, or breathing feebly or irregularly, manual artificial respiration must be instituted to facilitate the inhalation of the amyl nitrite. The insertion of 2 crushed ampules of amyl nitrite is repeated 4 times at 3- to 4-minute intervals until a total of 8 ampules is given.

(a) If hydrocyanic acid has disappeared from the surrounding atmosphere within a few seconds after the individual is stricken and the gas mask has not been put on, time should not be taken to adjust the mask. Two ampules of amyl nitrite may be crushed in the hollow of the hand and held close to the patient's nose. As above, administration is repeated every 3 or 4 minutes until a total of 8 ampules is given. Artificial respiration should be continued

until spontaneous regular respiration returns. Treatment should be continued for at least 10 minutes after the last sign of cardiac activity.

(b) Where available, sodium nitrite and sodium thiosulfate should be administered intravenously. Ten cc. of a 1 percent solution of sodium nitrite should be injected intravenously over a period of 1 minute every 10 minutes until a total of 50 cc. is given. Between the nitrite injections, 10 cc. of a 10 percent solution of sodium thiosulfate should be given intravenously over a period of 1 minute.

(c) Amyl nitrite administration may lead to a marked but temporary and not dangerous fall in blood pressure. The decrease in blood pressure following sodium nitrite injections is negligible unless the patient is allowed to get into an upright position. The development of a slight degree of cyanosis is evidence of a desirable degree of methemoglobinemia. It is not anticipated that, at the above dosages, an extreme or injurious degree of methemoglobinemia will develop. If it does, however, it should be treated by 100 percent oxygen inhalation.

31. CYANOGEN CHLORIDE (CK)

A. Properties

Cyanogen chloride is a colorless liquid which boils at 15° C., yielding a volatile irritant vapor. Although only slightly soluble in water, it dissolves readily in organic solvents. Its lethal concentration for 10 minutes exposure is 0.40 mg. per liter.

B. Pathology

The acute toxicity of cyanogen chloride is similar to that of hydrocyanic acid. The respiratory center is at first stimulated and then rapidly paralyzed. Cyanogen chloride, like phosgene damages the respiratory tract resulting in mild inflammatory changes in the bronchioles, congestion and edema of the lungs. The edema may form much more rapidly than in phosgene poisoning.

C. Symptoms

The signs and symptoms combine those produced by a lung irritant and hydrocyanic acid. Very low concentrations produce lacrimation. Following exposure there is an immediate intense irritation of the nose, throat and eyes, with coughing, choking, tightness in the chest, and lacrimation. Thereafter, the exposed person may become dizzy and increasingly dyspneic. Unconsciousness is followed by failing respiration and death within a few minutes. Convulsions, retching, involuntary urination and defecation may occur. If these effects, typical of cyanide poisoning, are not fatal, the signs and symptoms of pulmonary edema may develop. There may be persistent cough with much frothy sputum, rales in the chest, severe dyspnea and marked cyanosis.

D. Treatment

Adequate protection against field concentrations of CK is provided by all Navy gas masks with canister markings of B, BA, BB, B1, B2, and Bx. On detection of the gas, the breath should be held and the gas mask should be adjusted. Treatment is a combination of measures for hydrocyanic acid and for phosgene poisoning. (See pars. 5D and 30E, pp. 5 and 39.) The predominant signs and symptoms determine therapy.

E. Prognosis

If death does not occur promptly from cyanide, the outlook is determined by the severity of the manifestations of lung irritation.

32. ARSINE (SA)

A. Properties

Arsine is a colorless, odorless gas, but when impure it may have a garlic-like odor in high concentrations.

B. Pathology

The gas is absorbed from the respiratory tract into the blood and gives rise to intravascular hemolysis. This results in anemia, hemoglobinemia, methemoglobinemia, and hemoglobinuria. Through the action of circulating arsine and its oxidation products there is serious disturbance of the tissue metabolism of the kidney and liver. The kidneys show marked tubular change and numerous blood pigment casts. Anatomical changes in the liver are less constant, but hepatitis and focal necrosis may be present. Jaundice is due to hemolysis or to liver damage or both. Death results from renal or hepatic failure, anemia, or a combination of these.

C. Treatment

Therapy is both symptomatic and specific. The symptomatic treatment consists in the daily administration of about 3,000 cc. of fluid, either orally or parenterally as isotonic saline and dextrose; blood transfusions of 500 cc. each, repeated so as to maintain the hemoglobin above 50 percent and the red blood count above two million per cu. mm.; and the daily administration of 20 grams of sodium bicarbonate in divided doses. The specific treatment is the same as that for lewisite poisoning and consists in the intramuscular injection of BAL. (See par. 11E(4), p. 25.)

Section IX

INCIDENTAL GASES

33. GENERAL

This group includes carbon-monoxide, nitrous fumes, hydrogen sulfide and ammonia. These may be encountered in dangerous concentrations in confined or poorly ventilated spaces as well as in accidents aboard ship.

Protection against incidental gases: The service mask and collective protectors are of no value against carbon monoxide, ammonia and of only limited value against nitrous fumes and hydrogen sulfide. A special type of canister is required for protection against carbon monoxide and hydrogen sulfide.

34. CARBON MONOXIDE

A. Physical Properties

Carbon monoxide is a colorless, odorless gas, which is lighter than air, into which it diffuses rapidly.

B. Occurrence in Military Operations

Carbon monoxide is formed by gun blasts, bursting shells, internal combustion engines, exhaust, fires in confined spaces of ships, and in the incomplete combustion of fuels. Dangerous concentrations are apt to occur in confined spaces such as poorly ventilated engine rooms, hangar decks of aircraft carriers, tank landing craft, garages, poorly ventilated gun turrets or emplacements, and in mining operations.

C. Pathology

Asphyxiation is produced by the inactivation of hemoglobin through combination with carbon monoxide. The resultant anoxia produces nervous system changes. Post mortem examinations reveal little beyond the characteristic cherry red color of the blood and hemorrhages in the brain. The dissociation of carbon monoxide from hemoglobin may be hastened by oxygen.

D. Symptoms

Carbon monoxide is very insidious in its action and poisoning may occur with appreciable initial signs. The symptoms progress from throbbing headache, vertigo, yawning and poor visual acuity, to the development of cherry red mucous membranes, weakness and coma, subnormal temperature, feeble pulse and perhaps death.

E. Diagnosis

The diagnosis is made from circumstances of exposure and the appearance of a cherry red color of the skin and mucous membranes.

F. Protection

Adequate ventilation should be provided for all enclosed spaces where carbon monoxide may be produced. The safety of the air in the space for men to breathe may be tested by means of a standard carbon monoxide indicator.

G. Treatment

Remove to pure air, give oxygen or oxygen-carbon-dioxide mixture, and artificial respiration if necessary. Rest, blankets, and warm drinks are also indicated. Blood transfusions are valuable in desperate cases.

H. Prognosis

The longer the period of coma the less the chance for recovery. Most mildly exposed individuals recover with early treatment. Tachycardia and dyspnea may continue for months and there may be central nervous system disturbances ranging from simple neuritis to mental deterioration.

35. NITROUS FUMES

A. General

The term "nitrous fumes" applies to the mixture of oxides of nitrogen which is liberated when high explosives are burned or detonated. Nitrous oxide has anesthetic properties in high concentrations. It possesses no irritating action. Nitric oxide combines rapidly with oxygen to form nitrogen dioxide which is a dark brown gas. Nitrogen dioxide reverts to nitric oxide when it passes through the gas mask and also forms N_2O_4. The latter compound reacts with water to form nitrous and nitric acid.

B. Occurrence of Poisoning

The danger of nitrous fume poisoning is great if high explosives, such as smokeless powder or cordite, are burned or detonated in the absence of sufficient ventilation. This may occur in gun pits, armored vehicles, ship magazines and turrets, as well as in mining and tunneling operations.

C. Pathology

Nitric oxide, NO, combines with hemoglobin to form NO-hemoglobin. It is doubtful, however, whether this latter compound exists in the body during life. Inhalation of nitric oxide causes the formation of methemoglobin but does not appear to lead to any tissue lesions. Inhalation of nitrogen dioxide results in the formation of nitrite and hence leads to a fall in blood pressure and to the production of methemoglobin. Inhalation of high concentrations of nitrogen dioxide (above 0.5 mg. per liter) causes rapid death without the formation of pulmonary edema. Somewhat lower concentrations

result in death with the production of yellow frothy fluid in the nasal passages, mouth, trachea and marked pulmonary edema. The findings in other tissues are negligible.

D. Symptoms

The symptoms following inhalation of "nitrous fumes" are due chiefly to nitrogen dioxide. The symptoms depend upon the concentration of the gas. At exposures to concentrations less than 0.005 mg. per liter over long periods of time, inflammation of the gums, emphysema of the lungs, hypotonia and bradycardia have been observed. At exposures to higher concentrations, there is severe local irritation with burning and choking in the chest, violent cough, expectoration of yellow colored sputum, headache and vomiting. A latent period of 2 to 24 hours then follows. The late symptoms start with coughing, nausea, vomiting, frothy sputum, dyspnea, cyanosis, convulsions and symptoms of lung edema. This train of symptoms may result in death. At exposures to very high concentrations for short period of time, the onset of symptoms is very sudden and marked. Convulsions, unconsciousness and respiratory arrest occur within a short time and death may follow.

E. Diagnosis

The diagnosis is made from the history, the symptoms described, and sometimes from the pungent odor of the gas or the yellow discoloration of the exposed mucous membranes.

F. Treatment

Treatment of casualties with symptoms of pulmonary irritation is the same as that outlined for phosgene poisoning. (See par. 5D, p. 5.) The few cases with symptoms referable to the central nervous system either die quickly or, on removal to fresh air, recover spontaneously.

G. Prognosis

Fatal cases usually die within 48 hours. Bronchopneumonia and varying degrees of pulmonary fibrosis and emphysema often follow recovery from the acute stage.

36. HYDROGEN SULFIDE

A. General

This colorless gas in low concentrations has the odor of rotten eggs. In high concentrations it may dull the sense of smell and be difficult to recognize. Hydrogen sulfide is nearly as toxic as hydrocyanic acid. It is produced during decomposition of sulfur containing compounds in sewers, waste coal bins or stacks, holds of ships and water front excavations.

B. Pathology

In low concentrations, less than about 0.5 mg. per liter, hydrogen sulfide may produce inflammation of the eyes, nose and throat if breathed for periods of one-half to one hour. Somewhat higher concentrations may produce edema of the lungs. Still higher concentrations 2 mg. per liter or greater, are rapidly fatal, presumably by combination of the hydrogen sulfide with the tissue respiratory pigments and the subsequent paralysis of the respiratory center.

C. Symptoms

The symptoms depend upon the concentration of the gas. At the lowest concentrations, the effects are chiefly on the eyes; that is conjunctivitis, swollen eyelids, itchiness, smarting, pain photophobia and blurring of vision. At somewhat higher concentrations, respiratory tract symptoms are more pronounced. Rhinitis, pharyngitis, laryngitis, and bronchitis may occur. Pulmonary edema may also result. At very high concentrations, unconsciousness, convulsions and cessation of respiration develop rapidly.

D. Treatment

The patient should be removed immediately from the contaminated atmosphere. Artificial respiration and, if possible, inhalation of oxygen should be instituted immediately. Treatment of pulmonary edema is the same as that caused by phosgene. (See par. 5D, p. 5.)

E. Prognosis

Mortality from severe exposure is high. When there are symptoms of lung damage the prognosis is like that in phosgene poisoning. (See par. 5F, p. 7.)

37. AMMONIA

A. Physical Properties

Ammonia is a colorless gas which is soluble in water and has a pungent, characteristic odor.

B. Occurrence in Military Operations

This gas has not been used in warfare but may be encountered in industrial accidents, bombings involving refrigeration plants and in holds of ships as a product of decomposing material.

C. Pathology

Exposure to high concentrations of ammonia produces prompt and violent irritation of the eye and respiratory tract. There may be spasm and edema of the glottis or necrosis of the laryngeal mucous membranes. Pulmonary edema may develop as in phosgene poisoning and may be complicated by bronchopneumonia.

D. Symptoms

Inhalation of high concentrations produces violent, burning pain in the eyes and nose, lacrimation, sneezing, pain in the chest, cough, spasm of the glottis, and pulmonary edema. Often there is a temporary reflex cessation of respiration with spasm of the glottis. Edema of the glottis at a later period may seriously interfere with breathing. Concentrations of 0.1 percent are intolerable to man. Liquid ammonia is vesicant.

E. Treatment

Treatment consists of prompt removal to pure air, and artificial respiration. Later measures are directed toward the treatment of pulmonary edema, bronchitis and pneumonia. (See par. 5D, p. 5.)

F. Prognosis

The mortality is high following severe exposure with low concentrations, recovery is usually rapid, although bronchitis may persist.

38. FIRE HAZARD ABOARD SHIP

Fire aboard naval vessels produced by explosions, incendiaries or other causes creates an extremely important problem. The cause of death aside from blast and direct flame may be due to anoxia, carbon monoxide, heat, nitrous fumes, smoke, etc. The Navy oxygen rescue breathing apparatus (Type A1) is supplied by the Bureau of Ships for protection under these circumstances. This rebreather type of apparatus may not be available to all personnel. The question arises as to the limitations of the Navy service gas mask as a possible life-saving measure in an emergency.

The following is quoted from the Fire-Fighting Manual, Bureau of Ships, Navy Department, 1943, page 64:

"The canister of the Navy service gas mask, which is designed to protect the respiratory system of the wearer against the effects of war gases, will provide only limited protection against smoke. The duration of the protection is dependent upon the type of smoke and its concentration. The canister 'does not generate oxygen' but filters smoke and many of the gases out of the air as it passes through the canister. Therefore, the service gas mask should *not* be used in air containing less than 16 percent of oxygen or in air having heavy concentrations of smoke from oil fires, except for very short periods of time. In every case that the smoke penetrates the gas mask a new canister should be provided prior to further use."

It will be noted therefore that the standard Navy gas mask may be of some value in the absence of the Navy oxygen rescue breathing apparatus (Type A1). Personnel exposed to smoke should don immediately the gas mask in a serious emergency with these limitations in mind.

39. OXYGEN DEFICIENCY

A. General

(1) The proportion of oxygen in the atmosphere may be reduced to a dangerous degree by human consumption in closed or poorly ventilated spaces such as shelters, submerged submarines or underground tunnels, also by combustion, by fire, or dilution with other gases. A number of fatalities from anoxia have occurred in naval vessels incident to personnel without observing certain precautions, entering spaces which have been sealed for long periods. The depletion of oxygen has resulted from a number of causes, such as the action of linseed oil paint which abstracts oxygen from the atmosphere in a sealed space under certain circumstances and certain fermenting fruit cargoes. (See Bureau of Ships Manual, Navy Department, Article 608-612, Chapter 6, i.e., for precautions to be followed in entering such spaces.) The absolute reduction of oxygen at high altitudes while mainly of concern to aviation, may also require consideration in land operations in mountainous areas.

(2) A normal 70 Kg.-man while resting in bed requires 0.240 l/min. of oxygen. Consumption is increased with activity to 1.2 l/min. while walking at a rate of 4 miles per hour and to 3 to 4 l/min. at maximum exertion.

B. Symptoms

(1) When the oxygen of the inspired air is decreased to values between 16 and 12 percent (a candle is extinguished at 17 percent), the volume of breathing is increased and the pulse rate is accelerated. The ability to think clearly is diminished. Finer skilled movements are disturbed.

(2) When the oxygen of the inspired air is decreased from 14 to 10 percent, judgment becomes faulty, injuries may cause no pain, emotions are volatile, and muscular effort causes easy fatigue.

(3) When the oxygen is decreased from 10 to 6 percent, nausea and vomiting may appear. Bewilderment and loss of consciousness follow and muscular movements may be impossible. The subject may be wholly unaware that anything is wrong.

(4) When the oxygen is diminished to below 6 percent, respiration consists of gasps separated by periods of apnea. Convulsive movements may occur. Respiration ceases and the heart continues to beat for a few minutes. Death follows rapidly.

C. Acclimatization

Initial exposure to anoxia at high altitudes may give rise to the above symptoms. After several days at high altitude, acclimatization takes place. There is an increase in the volume of breathing and of the red cells in the blood with a decrease of the alkali in the blood and of carbon dioxide in the alveolar air. This enables the individual to increase his activity toward normal.

D. Treatment

(1) The individual should be removed from the atmosphere to pure air if possible. At high altitudes and where removal to air is impossible, oxygen must be administered. If respirations have ceased artificial respiration should be given until at least 10 minutes after signs of cardiac action have disappeared. Oxygen should be administered by inhalation with or without the inclusion of 5 percent carbon dioxide.

(2) The individual exposed to low oxygen concentrations should remain recumbent and move as little as possible in order to diminish his metabolic needs for oxygen.

(3) It is obvious that a gas mask will not protect against oxygen deficiency.

E. Prognosis

(1) If the anoxia is corrected before consciousness is lost or shortly thereafter, most of the symptoms disappear within a few hours. Headache, nausea and malaise may continue for 24 to 48 hours.

(2) If anoxia has continued for a long period, degenerative changes may occur in the nervous system with paralysis or amnesia. Death occurs rapidly when the oxygen content of the inspired air drops below 5 percent.

A GUIDE FOR THE DISPOSITION OF PERSONNEL WITH BLISTER GAS BURNS

40. INTRODUCTION

A. General

This section, which will serve as a guide, is designed for the use of medical officers in the field, in the event they should be confronted with casualties due to blister gases. Its chief purpose is to bring to their attention the current views concerning the casualty-producing powers of blister gases. It will assist the medical officer in the forward area in deciding which type of blister gas case he should evacuate as a casualty, and which type he may retain in the front lines without appreciable interference with the fighting effectiveness of the individual. The management and treatment of blister gas injuries in contradistinction to disposition have been specifically omitted since they are considered in other sections of this manual.

B. Statistics

In the years 1917–1918 large numbers of allied troops with mustard gas burns were needlessly evacuated from the front lines before medical officers came to realize the true significance of the lesions and the limitations of their casualty producing power.

CHART I—CASUALTIES OF WORLD WAR I

Analysis of 6980 mustard gas cases from World War I

Location of burns	*Percent*
Eyes	86
Respiratory tract	75
Scrotum	42
Face	27
Anus	24
Legs	11
Buttocks	10
Hands	4
Feet	1.5

C. World War II

During the course of the present war, investigations have been made of the influence of blister gas burns on the ability of troops to carry out common types of military duties. In several experimental installations in the United States, Canada, Great Britain and Australia, volunteers with varying degrees of military service ranging from recruits with a few months elementary training to

Figure 2. CASUALTY

Twelve hours previously this man was exposed to mustard gas vapor without a gas mask. At the time of photographing, his eyes were closed completely, but he made an effort to open the lids as shown by the contracted skin on the forehead. Photophobia was marked. Lacrimation was profuse; tears can be seen between the lids. The conjunctivae were injected and the eyelids slightly swollen and congested.

Rhinitis was also present, the man complaining of symptoms of a "cold in the head."

A few days later cough became troublesome and he developed aphonia.

Within 10 days the eye condition had subsided. The cough lasted for a week longer.

This man was classified as a casualty because of the marked interference with vision caused by blepharospasm and photophobia.

Figure 3. CASUALTY

Twelve hours previously this man was exposed to mustard gas vapor. At the time of photographing, blepharospasm was marked and he was experiencing considerable discomfort in moving the eyes. For a period of 4 days he was unable to separate the lids voluntarily. On forcing the lids apart with the fingers the conjunctivae were seen to be injected and the corneas were slightly hazy.

Neither lacrimation nor swelling of the lids was a prominent feature of this case.

Figure 4. NONCASUALTY

A single discrete lesion such as that shown in this photograph is of noncasualty significance because first, it does not interfere with locomotion and second, a protective dressing, which will remain in position during exercise, can be applied to a lesion of this size.

Large areas of intense erythema involving the buttocks require the application of a protective dressing. Friction of the clothing can easily break down the injured skin leaving raw excoriated areas of tissue exposed.

The subject of this photograph had additional severe lesions on the trunk which warranted a classification of casualty status. (See fig. 12) This single lesion of itself is not of casualty significance and if it existed alone, the man could continue with his duties.

fully trained troops with combat experience, have been burned with blister gas. The degree of disability produced was carefully evaluated on assault courses, route marches, or by simulated combat exercises in the field lasting over a number of days. The observations which were made served to demonstrate the limits of the casualty-producing powers of blister gas and, furthermore, indicated the types of lesions which may or may not cause disability, and have been the basis for this guide, which, however, is not intended to be an adequate substitute for clinical demonstrations of blister gas cases as a means of orientating medical officers in this subject.

D. Types of Blister Gas Cases

There are two broad groups of blister gas cases, the disposition of which will offer no problem to the medical officer. In the first group are those who are totally disabled, and therefore, incapable of either offensive or defensive operations regardless of the urgency of the military situation. These will be classified as casualties and

evacuated as such. Examples of injuries causing total disability are blindness, or vesication of extensive areas of the body, such as an entire limb or the front or back of the trunk.

In the second group, are those men who have been burned, but whose lesions are trivial and affect their military effectiveness slightly or not at all. They will be classified as non-casualties and returned to the front line accordingly, with or without treatment.

E. Partially Disabled

Between these two groups lies the indeterminate group of the partially disabled men who would be able to carry out certain types of military duties; but, would be unable to attempt more strenuous tasks. The disposal of such cases is most likely to present the greatest problem. This guide will direct attention to typical casualty and non-casualty injuries within this group. In disposing of such cases the medical officer will be influenced by a number of factors in addition to the severity of the lesions, such as; the urgency and nature

Figure 5. NONCASUALTY

This photograph shows mustard blisters localized to a comparatively confined area.

Cases of this type are classified as noncasualties (See figs. 6 and 6 A) with the application of a protective dressing full duties can be resumed.

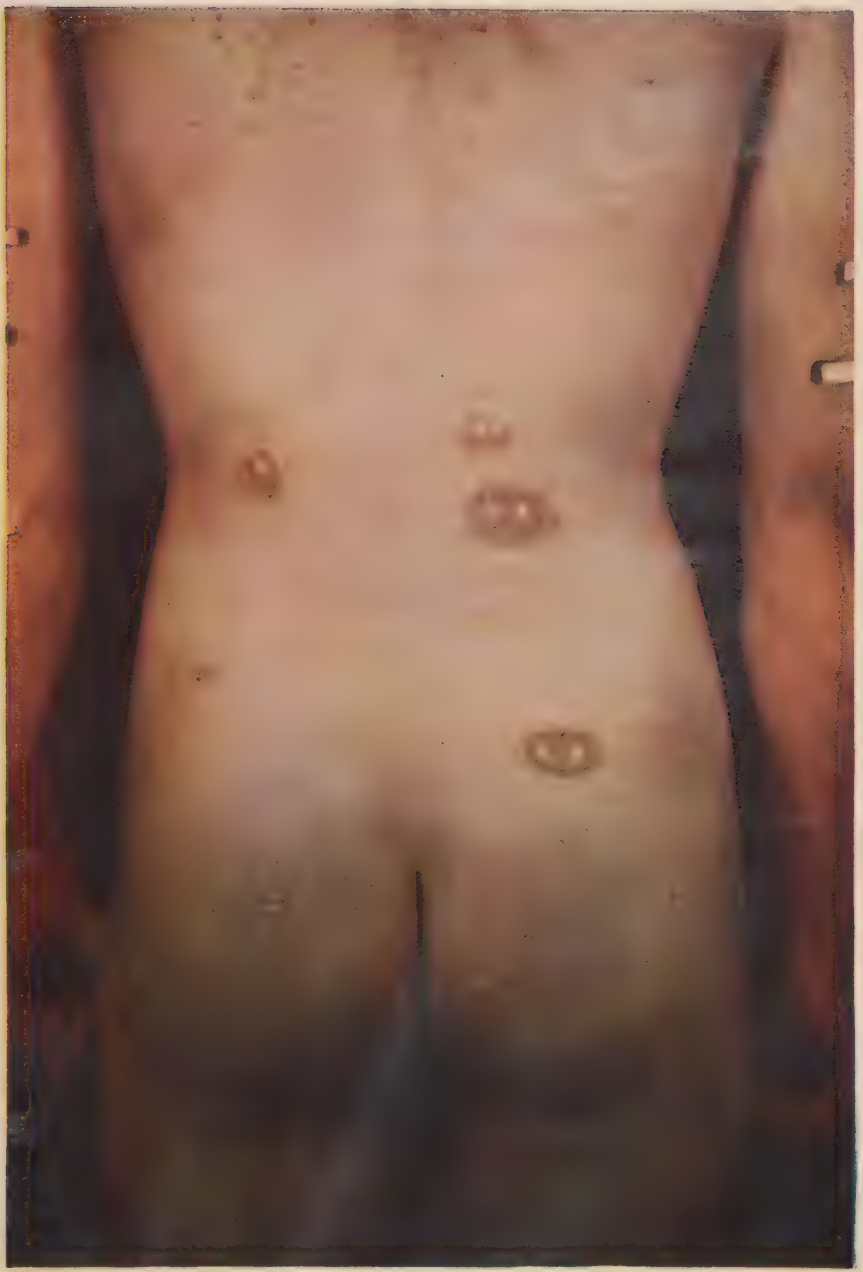


Figure 6. NONCASUALTY

Blisters in this location can be treated and a dressing applied which will allow the man to continue with his duties.

Two days before this photograph was taken this man was contaminated by mustard gas. Twenty-four hours after contamination, the small of the back was covered by erythema, which progressed to vesication by the following day. After that time, the lesions began to subside.

Figure 6A. NONCASUALTY

Twenty-four hours before this photograph was taken the man was exposed to mustard vapor, while wearing "fatigues" and impregnated underdrawers. This burn in no way interfered with work or recreation. The resemblance to sunburn effect is striking.

of the military situation, and the physical and mental make-up of the individual under consideration.

F. Differentiation Between Injuries Omitted

No effort has been made to differentiate between the injuries produced by the several blister gases which may be used by the enemy. This omission has been made purposely in the interests of simplicity. While there are several points of difference between the typical mustard and arsenical vesicant lesions, it is not recommended that the medical officer dealing with these cases in the field, attempt to dispose of them differently. The diagnostic features of the various blister gases and therapy peculiar to each are described in sec. III on vesicants.

41. EYE INJURIES

A. Disposition of Eye Patients

The correct disposition of personnel with eye lesions caused by blister gas is less of a problem to the medical officer than those involving the trunk and limbs. A very accurate estimate of the degree of impairment of vision resulting from eye lesions can be made by simple inspection.

B. Sensitivity to Mustard

The eye is more sensitive and more vulnerable to the action of mustard than any other part of the human anatomy. Approximately

85 percent of the mustard casualties in World War I had eye lesions of some degree. Exposure for 2 hours to a concentration of mustard vapor just barely perceptible by odor will produce eye lesions, but may not affect the respiratory tract or skin. There is no immediate symptomatic or local reaction to the absorbed agent: *a latent period* that varies with the degree of exposure precedes the onset of symptoms. This varies from 4 to 12 hours in the case of mild exposures, and may be reduced to 1 to 3 hours after severe exposures.

Figures 7A and 7B. NONCASUALTY

These men were exposed to a low concentration of mustard vapor. They had previously been exposed, on a number of occasions, to low dosages which produced no visible effects. Close inspection of the photographs will reveal the morbilliform rash characteristic of reactions of sensitized individuals.

C. Classification of Lesions

The lesions are divided into mild, moderate, and severe as follows:

(1) *Mild (75 percent of the cases in World War I):*

(a) The first symptoms include itching, lacrimation, a sensation of grit in the eye, followed by burning and sometimes by photophobia. There is hyperemia of both the palpebral and bulbar conjunctivae, the reaction in the

Figure 8. CASUALTY

The case shown in this photograph was contaminated by liquid mustard on the previous day. There is an old scar on the loin not related to the present condition.

latter usually beginning as a band-shaped area running transversely across the eye, with normal white bulbar conjunctiva above and below it. Edema of the lids may also be present. Hospitalization is seldom required, and recovery takes place in 1 to 2 weeks without classifying the individual as a casualty.

(2) *Moderate:*

(a) In this group there is complete closure of the eyes resulting from a combination of spasm and swelling of the lids. There is a latent period of 3 to 6 hours following exposure. Burning, itching, lacrimation, grittiness sensation, pain and photophobia are more severe than after mild exposures. *Blepharospasm* and blurring of vision appear. There is marked hyperemia and edema of the conjunctiva with a prominent interpalpebral band, edema of the lids, mild iritis, edema of the epithelium of the cornea, producing a roughened appearance like orange peel, although the stroma may be normal. The blepharospasm and edema of the lids may be so severe that the patient cannot open his eyes, and may even believe himself blind. Miosis is present early.

Figure 9. CASUALTY

This photograph shows extremely severe vesication of the entire surface of the buttocks. The upper half of the natal cleft was occupied by large coalescing blisters. The vesicated area extended across the perineum to the penis and scrotum which were severely affected.

This man was heavily contaminated due to liquid mustard on his trousers. After contamination he sat down for a number of hours, thereby pressing the contaminated clothing against the skin, allowing the vapor to pass upwards towards the perineum.

The photograph was taken 24 hours after exposure. The lesions continued to develop for 2 to 3 days. This man had a high fever for 4 days, nausea, anorexia, and suffered considerable mental distress incident to pain, insomnia, and the fear that the genital region had been permanently injured. He was detained in the hospital for 4 weeks.

(b) A muco-serous discharge is usually present, and although sterile in the early stages, it may cause the lids to stick together, causing accumulation of secretions in the conjunctival sac and predispose to infection. Since cases presenting this picture are temporarily blind, they will be evacuated as casualties. Early and prolonged hospitalization is required, with transfer to the care of an ophthalmologist if possible. Recovery from these lesions occurs in 1 to 6 weeks, and there is usually no visual loss. Return to duty will be determined by the extent of corneal injury, photophobia and blepharospasm.

(3) *Severe:*

(a) The latent period is short, lasting from 1 to 3 hours. There is deep ocular pain and headache, both of which may be severe, in addition to severe blepharospasm and blurred or dimmed vision. There is marked hyperemia and edema of the conjunctiva with a blanched area of ischemic necrosis in the interpalpebral portion, chemosis, and edema of the lids, which the patient cannot open. The epithelium and stroma of the cornea are damaged. Surface epithelium is hazy in the early stage, and will stain extensively or in a punctate manner with florescein within 24 hours. After 24 to 48 hours there is also edema of the stroma of the cornea and a deeper haze becomes apparent. Iritis and a muco-serous discharge are also present. If progressive, there may be dense corneal opacification, with deep ulceration and vascularization from the limbus. The cases with corneal ulcers heal slowly and may have relapses. Some may present perforations into the anterior chamber. These casualties require hospital care, and should be evacuated at the earliest possible moment.

(b) Droplets of liquid blister gas entering the eye may produce similar effects except that one eye alone may be involved or one eye may be affected more severely than the other. Droplets of lewisite or mixtures of lewisite and mustard in the eyes, in contrast to droplets of mustard alone cause immediate and painful spasm of the lids.

(c) In deciding as to the disposition of eye casualties the medical officer must assure himself that mild symptoms are not merely the early evidence of what promises to develop to severe inflammation, with temporary blindness within a few hours or a day. Reference to the time of exposure to the gas and rate of development of symptoms will guide him as to the course he should take. If the exposure occurred within the previous few hours, and the effects are increasing rapidly in severity, it is advisable to evacuate the case as a casualty in anticipation of the development of disabling effects within the next few hours. As a general rule it can be stated that the symptoms will reach a maximum within 6 to 12 hours.

42. RESPIRATORY EFFECTS

A. Mucous Membrane

The local action produced by mustard vapor, on the skin and eyes is matched by a similar necrotising action on the mucous membranes of the respiratory tract. Most of the inhaled vapor is absorbed or removed in the large respiratory passages and bronchi, and very little injury to the lung parenchyma results.

B. Lesions Produced

The most common respiratory lesions are due to prolonged exposure to relatively low concentrations of the vapor. In addition, severe casualties may result from men unknowingly exposing them-

selves to strong concentrations of mustard vapor. The fatiguing effect of low vapor concentrations on the olfactory organs, may follow after only a few minutes exposure thus masking the odor of the gas. More severe lesions can be expected in those unable to mask, e.g., unconscious casualties, or those with severe injuries to the face and both hands.

C. Latent Period

Lesions of the respiratory tract are characterized by a relatively long latent period before the onset of symptoms; usually 18 to 36 hours intervene between exposure and symptoms. Since the eye is much more sensitive to the agent, and is exposed simultaneously with the nares, respiratory tract lesions should be expected to follow all definite eye lesions, as well as vapor burns of the face in unmasked personnel. *Regard vapor burns of the face and eyes as precursors of lesions in the respiratory tract.*

D. Nasal Involvement

In the nose, the first visible effect is hyperemia of the mucosa and congestion of the submucosal blood vessels. This is followed by degenerative changes in the epithelium, varying with the degree of exposure from small focal ulcerations to large sloughing ulcerated

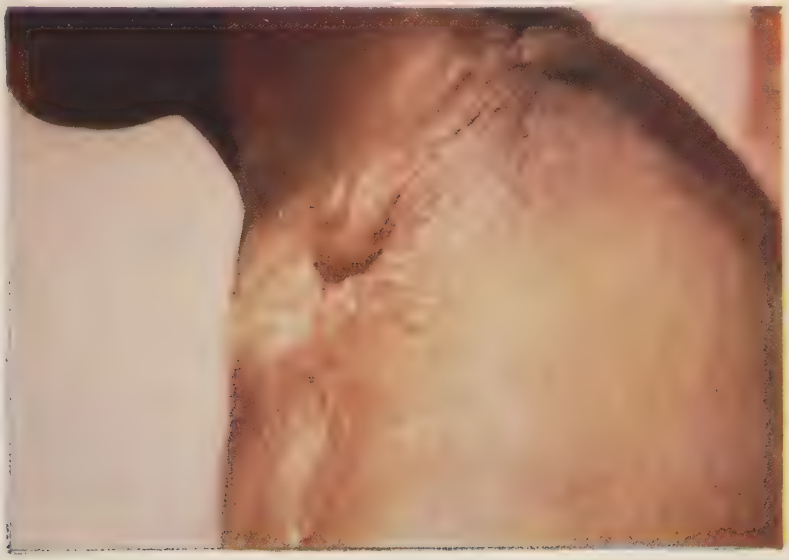


Figure 10. CASUALTY

An area of vesication extended around one side of the neck from back to front. This condition was caused by a splash of liquid mustard which contaminated the blouse.

It was found difficult to apply a protective dressing which would allow the man to carry on with his duties, including the wearing of his equipment. Without a dressing, the blister roof would be easily torn off, repeatedly irritated by the friction of the clothing and healing delayed. Such a lesion would bring about a state of partial disability. On these grounds cases of this type should be classified as casualties.

areas. Nasal symptoms consist of an early and profuse thin mucopurulent discharge. Epistaxis is rare. Nasal injury seldom occurs alone, and if it does, it is not usually a cause for hospitalization.

E. Pharyngeal Involvement

Acute inflammation of the pharynx usually appears 1 to 3 days after exposure to mustard vapor although there may be a delay of a week in moderate and mild cases. There is mild dryness and soreness of the throat, aggravated by swallowing, and rarely accompanied by regional lymphatic enlargement, unless secondary infection develops. Pharyngeal and laryngeal lesions may develop without significant nasal involvement, especially in mouth breathers. Upon inspection, the palate, uvula, tonsils and pharynx are engorged. Multiple white ulcerations may follow, varying in size depending on the severity of the exposure. Pharyngeal injury, like nasal involvement, is unlikely to occur alone; if it does, casualty status is not warranted.

F. Laryngeal Involvement

Laryngeal involvement is especially common as a result of inhaling mustard vapor, the lesions resembling those of the pharynx. Hoarseness, sometimes progressing to aphonia, may last 3 to 6 weeks, in rare cases longer. This lesion although not likely to require hospitalization, is almost invariably associated with other injuries to the respiratory tract.

G. Trachea and Bronchi Involvement

In the trachea and bronchi, depending on the dosage, a similar ulcerative and necrotizing inflammatory process in the mucosa follows contact with mustard vapor. The exudative process results in the formation of a pseudodiphtheritic membrane in the larynx, trachea, and large bronchi, which is fairly thick and tenacious. It may form a more or less complete cast of the lumen of the structures involved. This lesion may prove fatal, and requires early and prolonged hospitalization. In mild cases, however, small focal ulcerations occur, with hyperemia of the lining, epithelium, sub-mucosal edema and congestion, and an outpouring of mucus. Respiratory symptoms and signs suggestive of these lesions e.g., respiratory embarrassment, cough, tachypnea or cyanosis warrant prompt hospitalization.

H. Lung Parenchyma Involvement

The action of mustard on the lung parenchyma itself is usually insignificant. Secondary infection in the bronchi or alveoli may lead to lobular or lobar consolidation, and the course, symptoms, signs, and pathologic findings may then be dominated by the characteristics of the type of pneumonia present. The initial injury due to mustard in no way affects the choice of standard antibacterial

Figure 11. CASUALTY

Vesication of this extent is of casualty severity. Frequently a rise in temperature occurs. Nausea and vomiting may be present and add to the incapacitation caused by the burns.

These blisters were produced as a result of heavy liquid mustard which contaminated the uniform covering the back. No decontamination measures were applied. The uniform was worn for 4 hours after exposure to the agent.

Figure 12. CASUALTY

This case was classified as a casualty. Extensive areas of sharp erythema with pinpoint vesication were present within 2½ hours after exposure to the agent. The photograph shows the extent of these areas 48 hours after contamination.

Vesicated areas over the scapular region and the buttock require protection from the friction of the clothes and the pressure of equipment. Erythema with beginning vesication should be protected by a dressing, otherwise the affected skin tends to break down and the vesicated area may spread. It is difficult to apply, and retain in position, dressings which would protect areas to the extent shown here.

preparations to combat organisms that may be the cause of the secondary infection.

43. CUTANEOUS INJURY

A. Introduction

(1) Many attempts have been made to formulate clear-cut criteria which will enable medical officers to satisfactorily dispose of personnel reporting with blister gas burns. Experience in field trials at experimental installations has shown that no rigid rules or criteria can be defined which can act as a casualty yardstick. The most that can be done is to note the types and sites of lesions which have most frequently led to disablement in personnel who were exposed to blister gas in field trials, and who subsequently took part in simulated combat exercises, obstacle courses, marches or the like. From these observations the following facts have emerged and are summarized below:

(a) Widespread vesication of the trunk makes a man a casualty.

(b) Localized vesication makes a man a casualty, if it is situated in certain vulnerable areas of the body. Localized vesication in nonvulnerable areas is not of casualty significance, if the lesions can be satisfactorily protected to allow the man to continue with his duties.

(c) When produced by high dosages of vapor on masked personnel, and especially in tropical climates, burns are of casualty severity, partly because of changes brought about in the skin (edema and vesication), and partly the result of constitutional reactions which accompany the skin changes, such as nausea, vomiting, collapse and prostration.

(d) Burns produced by low dosages of vapor, while sufficient to bring about skin reactions such as edema and subjective symptoms (burning and itching) are not usually of casualty severity.

(e) When classifying a case as a casualty or noncasualty, the stage of development of the lesion must be taken into consideration.

B. Trunk and Neck

(1) *Extensive vesication of the trunk:* All the cases considered under this heading should be evacuated promptly as casualties.

(a) Extensive vesication may occur over the greater portion of one aspect anteriorly or posteriorly of the trunk. Under such circumstances the intervening area of skin will be involved by more or less severe erythema and pinpoint vesication. (See figs. 11, 13, and 14.) Vesication of this type is likely to occur more frequently on the back of the trunk than on the front. Possible reasons for this distribution are the protection afforded to the front of the trunk by webbing, ammunition pouches, etc. and the fact that the front of the uniform does not cling tightly to the body.

(b) Extensive vesication may be associated with constitutional effects such as fever, nausea and vomiting. These effects tend to occur more readily in tropical than in temperate climates.

(c) Secondary bacterial infection may complicate the course of the lesion at any stage. The medical officer in a forward position is not likely to see infection of large vesicated areas since such cases will have been evacuated to the rear medical services within the first day or two after contamination, that is, before secondary infection is likely to have developed.

Figure 13. CASUALTY

The greater portion of the back was vesicated. This man had a temperature of 100 to 101° F. for a few days. He was apathetic, depressed, nauseated, and lost his appetite for 5 to 6 days.

These lesions were produced by mustard sprayed from an airplane 2 days prior to this photograph. After contamination he wore his uniform for 4 hours. At the end of that time, patches of diffuse erythema had appeared on his shoulders. Twenty-four hours after exposure to the agent, the erythema was associated with swelling of the skin and pinpoint vesication.

In deciding the disposition of a case of this type, special note should be made of the rapid increase in the severity of the lesion over the first 24-hour period after contamination.

(2) *Localized vesication of the trunk:*

(a) Vesication occurring within or adjacent to the natal cleft (between the buttocks) usually calls for evacuation. Walking becomes increasingly difficult. Defecation is painful, and dressings require frequent changing. The lesion is usually most intense at the upper end of the natal cleft and may extend outwards over the buttocks and downwards along the walls of the cleft. (See figs. 8 and 9.) Severe vesication of the buttocks involving the natal cleft is usually due to sitting on heavily contaminated ground or for prolonged periods on contaminated trousers. (See fig. 9.) Under these circumstances the vesicated area is frequently seen to extend forward across the perineum to involve the scrotum and the penis.

(b) Trivial burns, such as only a mild erythema affecting the natal cleft, are not of casualty severity. These, however, require careful attention since walking or running aggravates the lesions and may break down injured skin, leaving excoriated areas and small intractable ulcers. Small discrete blisters may also be considered in this light, but when the blister gas encountered is mustard, vesication occurs as only part of more extensive lesions consisting of intense erythema and edema of the tissues, and such cases should be classified as casualties.

(c) Single discrete blisters on the buttocks apart from the natal cleft may be classified as non-casualties. (See fig. 4.)

(d) The majority of blisters on the trunk will require some form of protective dressing. Otherwise the blister roof will be torn off exposing the raw, sensitive floor to the friction of the clothing. The secretions tend to cause the clothing to stick to the blister floor thereby predisposing toward infection. In disposing of blister gas burns, the medical officer must decide whether or not it will be possible to apply protective dressings which will remain in position during active exercises.

(e) Examples of vesication on areas where permanent dressings are difficult to apply are shown in figs. 9, 10, 11, and 12.

(f) Blister gas burns of the trunk which may be considered as non-casualty severity are illustrated in figs. 5, 6, 7A and 7B.

(3) *Burns caused by exposure to high dosages of blister gas vapor:*

(a) After exposure to a high dosage of mustard gas vapor, especially under tropical conditions, nausea, vomiting and early symptoms of collapse, are usually evident before the erythema on the skin is completely developed. It is important to note that these effects occur even among personnel who wear masks during the period of exposure to the gas. Since these constitutional symptoms may persist for several days, during which time the skin burns will be increasing in intensity, cases of this type should be classified as casualties. Severe vapor burns of the trunk appear as generalized vivid erythema, (see fig. 15) with pale gray areas indicating sites which will eventually vesicate or become necrotic. It is common to see patches of skin where erythema is absent or mild. These represent areas where the clothing was pressed in close apposition to the skin, for example by a gas mask haversack or sling.

(4) *Burns caused by exposure to low dosages of blister gas vapor:*

(a) Mild vapor burns, while causing erythema, itching and irritation, are not casualty producing.

(b) It is to be noted again that the medical officer should always consider the interval after exposure in relation to the severity of the burns. A case which presents itself with apparently mild lesions may in fact be showing

the early effects of a severe exposure to a vesicant vapor. It will not always be possible to determine the period which has elapsed since exposure to the gas, but an effort should be made to do so. Factors that will help the medical officer to substantiate his decisions are the rapidity of the development of effects and the presence of constitutional symptoms.

Figure 14. CASUALTY

Widespread vesication caused by mustard extended from the shoulders to the buttocks. The skin between the vesicles was erythematous and edematous, and in many areas showed pinpoint vesication.

Severe discomfort, caused by stretching of the skin, accompanies lesions of this type. In addition, increase in temperature, nausea and vomiting are common, especially in tropical climates.

Burns of this severity, uncomplicated by secondary infection, require hospital treatment for at least 3 to 4 weeks followed by a period of convalescence.

(5) *Sensitization due to multiple exposures to mustard gas:*

(a) Attention should be paid to the characteristic appearance of "re-exposure" mustard gas burns, occurring in individuals who have been exposed to mustard gas 1 to 3 weeks (or more) previously. A small percentage of men who have been exposed more than once will become sensitized to the agent. Such individuals react differently both qualitatively and quantitatively.

(b) A sensitized man will usually show the effects of re-exposure by a rapid onset of symptoms. Erythema, with or without edema, and pronounced itching and burning, usually appear within 1 hour after exposure. Furthermore, less concentration of mustard vapor is required to produce effects in a sensitized individual than is the case in a non-sensitized man. If the erythema and edema are the result of exposure to a low dosage of mustard vapor, they will generally develop rapidly, and subside within 2 to 3 days. If vesication occurs, the time required for healing is the same as that in nonsensitized men.

(c) One of the most frequent occurrences in sensitized men, who have been reexposed, is the development of a morbilliform rash. Such a case is illustrated in figs. 7A and 7B. Another characteristic reaction is an eczematoid dermatitis, surrounding any previous lesions whether or not they have healed completely. Such a dermatitis may last for several days; it can best be compared with dermatitis venenata (poison ivy). Usually this type of reaction subsides within 48 to 72 hours after the individual is removed from the source of mustard vapor. Similar sensitization phenomena have been known to occur with lewisite and with the nitrogen mustards.

C. The Arms

(1) In a large proportion of the cases of blister gas injuries on the arms, the use of the limbs is not materially impaired, and when suitably treated, the individual is able to continue with all his duties. Vesication, when localized (See figs. 16 and 17) will produce little or no disability.

(2) Extensive vesication involving the axillae, the volar or dorsal aspects of the elbow frequently results in partial disablement, by impairing the movement of the limb at these points. Severe burns are most frequently associated with edema of the surrounding tissues which tends to immobilize further the movements of the limbs. The dorsal aspect of the elbow and forearm are common sites of severe burns since these areas, together with the knees, are points of pressure supporting the body when the individual drops prone on the contaminated ground and fires his shoulder arms from this position. The clothing covering these sites is thereby pressed into the ground and tends to pick up contamination in these areas. Typical lesions produced in this manner are shown in figs. 18 and 20. In each case severe edema was present together with widespread areas of vesication. Although the limb could be moved, such movements were painful. Cases of this type should be evacuated as casualties when the lines of communication are normal.

(3) Widespread vesication of the arms are usually associated with intense local reaction both factors combining to produce a state of

Figure 15. CASUALTY

Twenty-four hours before this photograph was taken this man, wearing a gas mask and protective shorts was exposed to a high dosage of mustard vapor in a warm climate.

Within 6 hours he became a casualty due to nausea and vomiting and generalized erythema involving the upper part of the limbs and trunk. The gastric symptoms persisted for 2 days.

During the ensuing 2 days the erythema continued to increase in severity, deepen in color and break out in pinpoint vesication at scattered areas. The axillae and flexures of the elbows were especially affected.

Such cases are classified as casualties soon after exposure.

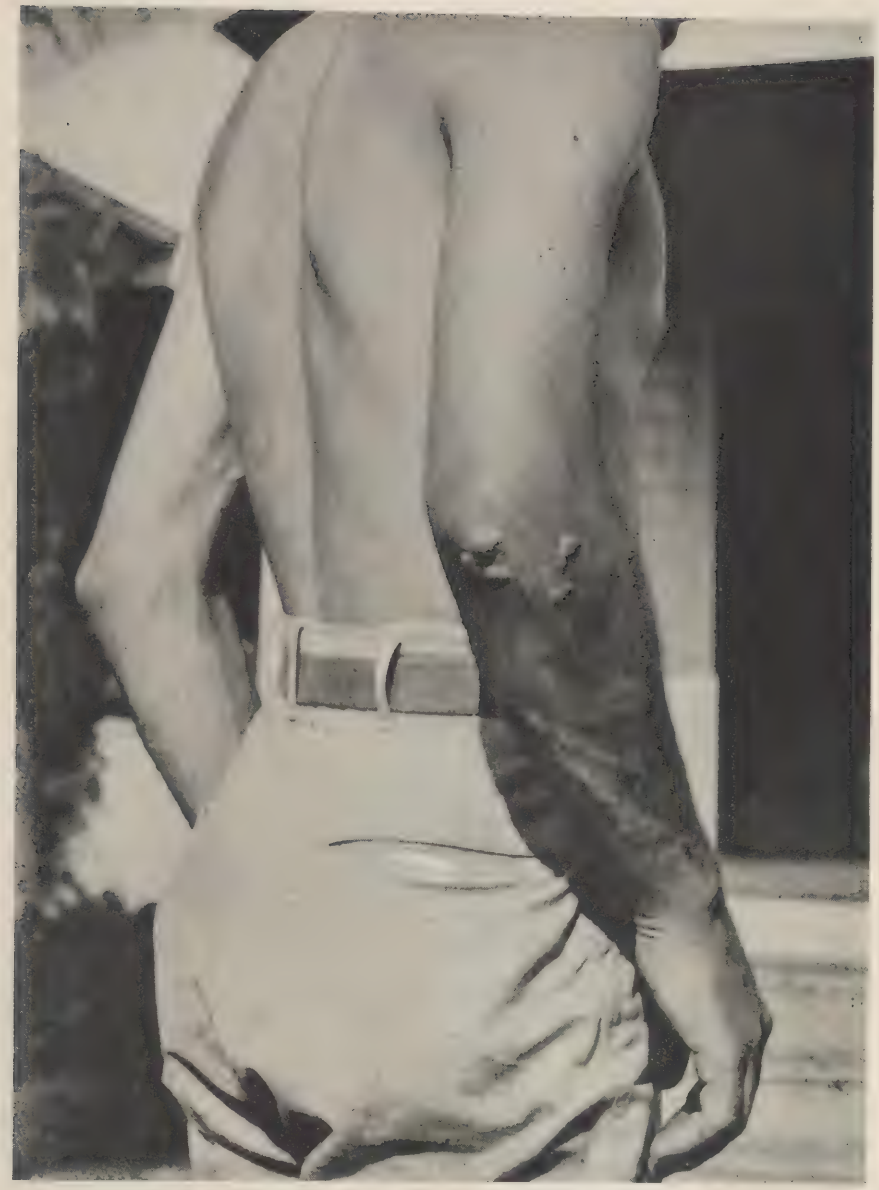


Figure 16. NONCASUALTY

These blisters were produced by liquid mustard gas through clothing. Contamination occurred one day previously.

The blisters were discrete and surrounded by an area of erythema with slight swelling of the tissues. When a protective dressing was applied, the man was able to continue with all his duties.

As a rule blisters involving the flexure of the limb tend to incapacitate more easily than similarly sized lesions elsewhere on the limb, because of aggravation and retardation of healing resulting from the constant movements of the joints. Blisters of the size shown here are of themselves not casualty producing. More extensive vesication in his area would have interfered seriously with the use of the limb and required that the individual be classified as a casualty.

partial disability. Cases of this type should be evacuated unless the tactical situation will not permit.

D. The Hands

(1) Medical officers may expect to frequently encounter blister gas burns of the hands. In general, burns affecting the hands tend to cause a degree of disability out of all proportion to the size of the lesions. Considerable care and judgment is called for in the correct disposition of such cases.

(2) Experience in tropical experimental installations indicates that, while adequate protection against high dosages of vapor can be provided by impregnated gloves and anti-gas ointment, it is difficult to avoid burns of the hands due to liquid blister gas, especially in heavily contaminated jungle.

(3) The palms of the hands are resistant to vesication. However, if sufficient amounts of liquid agent come in contact with the palms,

Figure 17. NONCASUALTY

These blisters were produced by liquid mustard gas which contaminated the uniform worn by the man 2 days previously. He discarded his contaminated clothing after 4 hours wear.

A lesion of this size is associated with edema of the tissues in the neighborhood of the blister. In some cases the edema involves the entire circumference of the limb, and may spread upward toward the elbow or downward toward the hands. A severe local reaction of that type would make a limb virtually unusable, and warrant a classification of casualty.

Under tropical conditions lesions produced through clothing by liquid mustard gas may be expected to increase in severity for 2 or 3 days after contamination. Under temperate weather conditions the lesions are later in appearing, and slower in developing to full maturity.

Figure 18. CASUALTY

The left forearm shows the effects of wearing a herringbone twill jacket, for ½ hours contaminated with liquid mustard gas. This man fell prone onto contaminated ground in the jungle, crawled a few yards, and fired a rifle from this position.

Exposure occurred 2 days prior to photographing the lesions. The elbow and upper third of the dorsal aspect of the left forearm were involved by a deep burn which was pale with incipient necrosis in the center and vesicated at the periphery. Edema involved the circumference of the elbow and the upper two-thirds of the forearm. The limb could be moved at the elbow but movements were painful and resisted by the individual. Lesions of this type and severity are of casualty significance for 2 or 3 weeks.

directly or through gloves or ointment, vesication can occur. (See fig. 21.) Blisters affecting the palms are characteristically painful and slow to heal. When the integument is removed a raw tender surface is exposed and epithelialization is slow.

(4) If the lesion is single and of limited extent (See fig. 21), little or no disability may result with suitable treatment, and the application of a protective dressing.

(5) Burns produced by a liquid agent on the dorsum of the hand result in a severe local reaction characterized by intense edema of the tissues of the back of the hands and of the fingers. Pain is a characteristic feature of such lesions and is intensified by any movement of the fingers or wrist. In this way a state of partial disablement is brought about. Burns of this type impair the ability of the individual to carry out any but the crudest actions of the fingers and hands. (See figs. 22 and 23.) Such cases should be regarded as casualties.

Figure 19. CASUALTY

This photograph was taken 24 hours after the man was contaminated by liquid mustard while walking through freshly contaminated undergrowth. He was wearing impregnated clothing, which was removed 4 hours after he became contaminated. The "doughnut" or ring-shaped area of blisters which surround a gray necrotic area at the elbow is a clear example of a severe burn which will require from 2 to 4 weeks to heal satisfactorily.

(6) In deciding the disposition of blister gas cases, the medical officer should remember that the lesions continue to increase in severity until the second or third day after exposure. Consequently when seeing cases exposed within the previous 24 hours, he should try to anticipate the condition of the lesion within a day or two. An individual exposed within the previous 24 hours who reports for treatment with apparently trivial blisters on the hands may be totally incapacitated the following day. (See fig. 22.) As a working rule, it may be stated that when an individual exposed to a vesicant gas, liquid or vapor, within the previous 12–24 hours shows sharp erythema of the dorsum of the hand with commencing vesication, it may be assumed that the lesion will progress within the next day or two to the extent that all the erythematous area will become vesicated. If this is extensive (e.g., involving half the hand or more) edema of the tissues will be also present. Under such circumstances, the individual should be evacuated as a casualty when first seen. If the examination is made 48 hours or more after the exposure the lesion may be considered to be maximal in size.

(7) More frequently the lesions will consist of a number of scattered small vesicles and limited areas of erythema. These cases can

be treated satisfactorily, and the individual returned to his duties. The main requirement is the protection of the tender area by means of a suitable covering.

(8) Exposure to vesicant vapor produces diffuse erythema involving the dorsum of the hand and wrist. With low dosages of vapor the condition does not proceed beyond erythema. High dosages cause generalized sharp erythema, edema of the tissues and vesication of the dorsum of the hand and fingers. In severe cases of this type, pinpoint vesication involves the entire dorsum of the hand and fingers, thereby totally disabling the hands. These cases will be evacuated as casualties.

E. The Lower Extremities

(1) The knees are most common sites of liquid blister gas burns on the lower extremities. This site, together with the ankles, frequently contains lesions which result in incapacitation of the individual by interfering with locomotion. Movements of the limb at the joints tend to aggravate existing lesions by increasing local edema. A further disabling factor is introduced by the discomfort attending the application and wearing of firm dressings to the points of maximum movement of the lower limb.

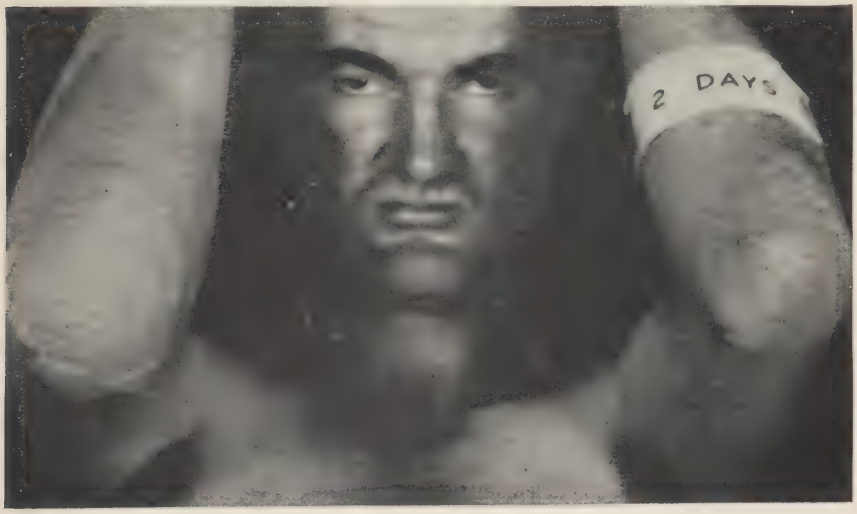


Figure 20. CASUALTY

This photograph was taken 2 days after exposure to mustard. The individual fired a rifle while lying on mustard contaminated jungle floor. As in the cases shown in figs. 18 and 19, he wore his contaminated clothing for 4 hours.

The pale center of the annular vesicle involving the right elbow indicates a deep burn, the center portion of which will eventually become necrotic leaving a slowly healing wound. Severe edema involves the forearm.

After 2 weeks the limb was still swollen and the lesions had not yet healed.

Blister gas burns of this type and position produce a casualty for approximately 3 to 4 weeks. If secondary bacterial infection occurs, the healing time will be lengthened considerably.

(2) It has been mentioned above under "C- The Arms" that when an individual is compelled to fall prone onto the ground in a contaminated area the elbows and knees become points of pressure, and lesions tend to develop on these sites with greater frequency than elsewhere. Vesication frequently spreads over the kneecaps, upward on the thighs, and downward on the legs. These burns tend to be extensive and deep and are frequently associated with edema. Edema involves not only the immediate site of the burns, but often extends

Figure 21. NONCASUALTY

The palm of the hand is resistant to vesication. Prolonged contact with the liquid vesicant agent is necessary to produce blisters in this area. The photograph shows a hand on which a glove was worn that was contaminated with liquid mustard gas for ½ hours. Exposure occurred 2 days prior to the photograph. The blister was treated, a protective dressing applied, and the individual continued with his duties.

Blisters on the palm of the hand are painful. If denuded a raw tender area is exposed which is slow to heal; consequently, a protective dressing is necessary.

In the present case the individual experienced discomfort for several days in handling objects, but discomfort alone is not usually regarded as a casualty producing factor.

Figure 22. CASUALTY

The dorsum and fingers of each hand were vesicated. The remainder of the skin was erythematous, and the tissues markedly edematous especially on the left hand. The hands were virtually useless and the individual was classified as a casualty.

Pain of a burning and throbbing nature sufficient to prevent sleep for a few days is a prominent feature of severe blister gas burns of the hands.

Two days previously, this man crossed an area of jungle contaminated with liquid mustard gas. Even though his hands were covered by impregnated gloves worn over anti-gas ointment, he accumulated sufficient mustard on his glores to produce these burns.

as high as half way up on the thigh and half way down the leg. (See fig. 29.) In view of the interference with locomotion, pain caused by movements, and the tendency of such lesions toward delayed healing it will be advisable for medical officers to evacuate all such casualties presenting these lesions.

(3) In general, burns of the leg are more incapacitating than burns of the thigh. This is especially true of the calf of the leg, the pretibial area, and the ankle.

(4) It has been shown in simulated combat exercises in experimental installations that in numerous cases the presence of many superficial blisters on the legs and thighs alone is not sufficient to render a man incapable of carrying out routine military duties. The type of case referred to is illustrated in figs. 24, 25, 26 and 27. Individuals with lesions such as these with suitable dressings were able to take part in daily marches, gun drill and the like. In disposing of cases with lesions of this type and extent, in addition to the clinical findings, the medical officer will take into consideration additional factors which should influence his decision, such as the mental and

Figure 23. CASUALTY

Blister gas burns of this severity are always of casualty significance.

This photograph was taken 48 hours after the exposure, the lesions having reached full maturity by that time. The dorsum of the hand was grossly erythematous and the ulnar half was occupied by a large blister. The dorsum of each finger was vesicated and the skin stretched tight with edema.

In addition there were 6 discrete blisters on the palm of the hand, an area which is resistant to vesication except by prolonged contact with liquid mustard gas.

The hand was tender to touch, pain was severe and was of a throbbing nature accentuated by holding the hand in the dependent position. This case required 4 weeks hospital treatment before the lesions were sufficiently healed to allow him to be discharged to duty.

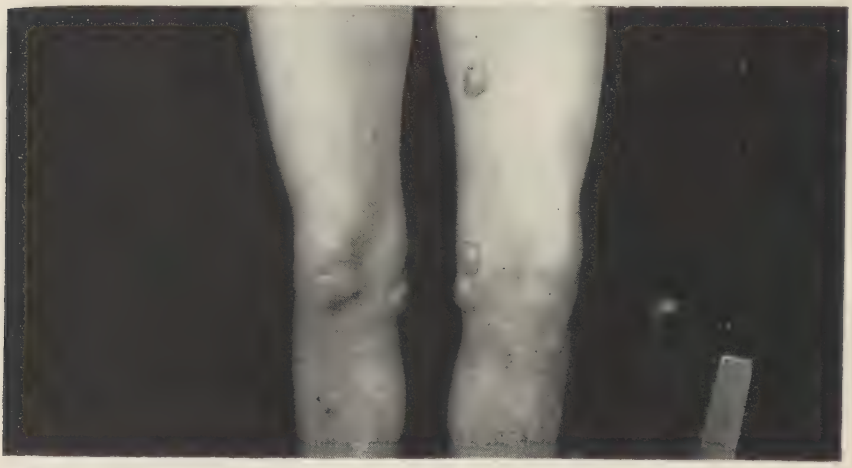


Figure 24. NONCASUALTY

This plate shows a number of blister gas burns on the legs of an individual sprayed with mustard gas from an aircraft 2 days previously. He wore his contaminated clothing for 4 hours. When suitably protected by dressings, which may be expected to remain in position during active exercise, the individual may return to full duty.

physical make-up of the individual, his willingness to continue with his duties, and the tactical situation existing at the time. Such cases will fall into the category of partially disabled personnel. After suitable protective dressings have been applied, men with good morale and robust physiques may be returned to duty as noncasualties.

(5) Reference has already been made to the influence of the site of the lesion on the degree of incapacitation. A relatively small

Figure 25. NONCASUALTY

A man with vesication of this extent is on the border line of the casualty state. The individual blisters escaped the bends of the knees; therefore, they were not constantly aggravated by the movements of walking or running. Furthermore, the vesicant agent was lewisite, which tends to produce discrete blisters with a narrow zone of erythema in contrast to mustard, which causes a more severe reaction over a wider area around the blister.

This man claimed that he was able to continue with his duties. After the application of a protective dressing he took part in daily route marches or mild duties such as gun drill. The blisters continued to make satisfactory progress during the ensuing 10 days.

blister or group of blisters situated in the popliteal area may reduce significantly the efficiency of a man to the extent that he should be evacuated as a casualty. (See fig. 30.) This is due largely to the interference with ambulation and the aggravation of the lesions by any movement of the limbs. At the same time it does not follow that any blisters affecting these areas are necessarily casualty producing (fig. 28). Effects, such as local inflammation and edema, the presence of infection, and the extent of the lesions on other parts of the body should be borne in mind when deciding the disposition

Figure 26. NONCASUALTY

A single vesicle is not necessarily of casualty significance.

The individual whose knee is shown in this photograph sustained a severe lesion just above the kneecap. The local reaction did not seriously interfere with locomotion and after a firm dressing had been applied he was able to continue with his duties.

The importance of the site of a lesion in relation to its incapacitating effects has been referred to previously. A lesion of the type shown in this photograph would be of casualty severity if it were situated in the bend of the knee.

Figure 27. NONCASUALTY

This shows erythema and pigmentation of the legs 72 hours after exposure to mustard vapor. There had been superficial vesication of the knees. This man was able to perform all of his duties and to complete an obstacle course without difficulty. The erythema is demarcated at the upper thigh because of impregnated undershorts that were worn during the exposure.

of the individual. In this respect, the available evidence from trails in the field with mustard and lewisite gas indicates that the mustard blister, size for size, is potentially more incapacitating than the lewisite blister. The main reason for this is the tendency of the mustard blister to be surrounded by a diffuse area of erythema and edema, while the lewisite blister is usually circumscribed with little local reaction in the neighboring tissues.

(6) A not uncommon site for the development of vesicant lesions is in the vicinity of the ankle at the level of the top of the shoes. A vesicant area frequently circumscribes the limb at the point of least protection between the shoes and the leggings. Such a lesion is associated with severe pain due to circulatory impairment and tense edema of the entire lower limb. Cases of this type should be evacuated as casualties on the grounds that movements of the limb tend to aggravate the severity of the condition and to seriously retard healing in addition to interfering with locomotion.

(7) Vapor burns of legs tend to be aggravated in the popliteal spaces. Pin-point vesication is frequently found in these areas associated with local edema. After exposure to higher dosages, intense erythema with scattered area of vesication may be seen over the entire surface of the leg. While such lesions are invariably of casualty

Figure 28. NONCASUALTY

Small, discrete and superficial blisters do not necessarily make a man a casualty even though they affect the skin in close proximity to the bend of a limb.

This photograph shows blisters which affected the left leg within a few inches of the bend of the left knee. Each blister was surrounded by a diffuse area of erythema. With a suitable protective dressing this man was able to continue his duties without impairing of efficiency.

It is not likely that an individual would be incapacitated even though he might experience considerable discomfort with blisters of this size and distribution, even though treatment were not available.

producing significance, they are in addition always accompanied by severe burns in other parts of the body and frequently with severe systemic effects.

(8) Mild vapor burns of the legs produce the characteristic irritation and itching common to all widespread vapor burns. While such effects are troublesome, they are not of casualty producing significance, and men so affected should be returned to their duties.

(9) Extensive vesication of the feet is not common. The thick skin of the soles is resistant to vesication. Furthermore it is protected by the sole of the shoe unless in a bad state of repair. Blister gas burns on the dorsal aspect of the foot are often associated with a sharp local reaction similar to that seen on the backs of the hands. Cases with burns of this type, especially if widespread over the foot, find it difficult or impossible to wear shoes and will require evacuation. Small discrete blisters may be of noncasualty significance. They may be effectively protected to allow wearing of the shoes and walking with little discomfort.

F. The Genitalia

(1) The genital region, next to the eyes and the respiratory tract is the most sensitive area of the body to blister gas burns. In World War I many casualties were produced by mustard gas burns of the genitalia. The majority of these burns were caused by mustard vapor. While the present methods of protection against blister gas include special impregnated garments designated to protect the genitalia, nevertheless, when blister gases are employed in chemical warfare, medical officers (especially in tropical theaters of war) may

Figure 29. CASUALTY

This picture demonstrates the severe reaction produced by a mustard blister on the lower third of the left thigh. An annular vesicle with a pale parchment-like center is seen to occupy the lower third of the ventral surface of the thigh. This is surrounded by a wide area of erythema which extends downward over the knee and around the circumference of the limb.

This burn, associated with a continuous throbbing pain was made worse by any movement of the limb.

Cases showing this combination of extensive vesication and swelling of the tissues should be regarded as of casualty significance even though only one limb is involved.

This photograph was taken 24 hours after contamination. A reaction, as severe as that depicted, shows that the individual had been exposed to a severe liquid contamination for a prolonged period. The severity of the burn may be expected to increase during the following day or two.

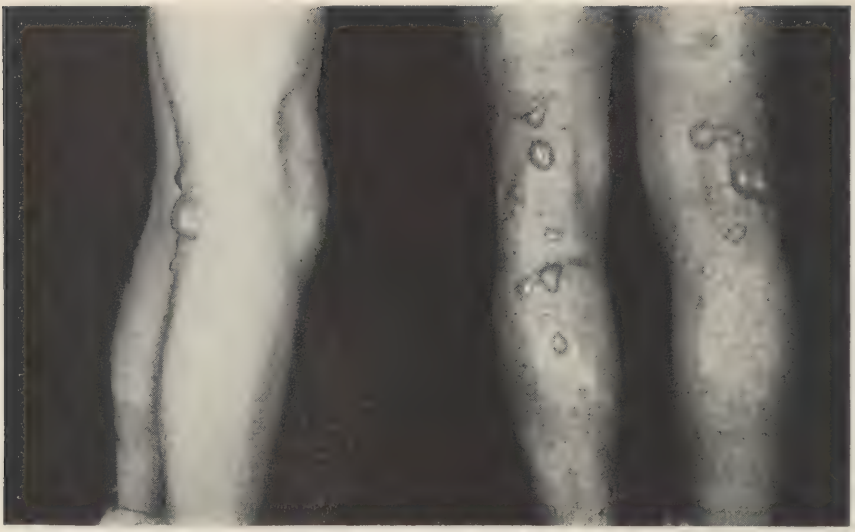


Figure 30. CASUALTY

This photograph was taken 48 hours after the man had been sprayed with mustard gas from an aircraft. He discarded his contaminated clothing after 4 hours wear. Mustard blisters of this type situated in the bends of the limbs are usually of casualty significance. Locomotion is impaired by the pain and discomfort brought about by movements of the joints. Prolonged marching or running tends to aggravate the local reaction in the tissues, which is usually an accompaniment of mustard gas burns. This is in contrast with the findings of lewisite burns which are usually circumscribed with a more localized reaction in the surrounding tissues.

Figure 31. CASUALTY

Case presenting this appearance within 24 to 48 hours after the exposure to mustard vapor should be evacuated as a casualty. In all cases the edema is likely to increase in amount and in some cases, within the following few days, will assume massive proportions. (See fig. 33.)

Edema fluid accumulates most readily at the prepuce.

Because of the normal pigmentation of the skin in these areas erythema is rarely conspicuous on the scrotum or penis except after exposure to high dosages. Deepening of the normal pigmentation may be evident after 1 or 2 weeks.

be confronted with a large number of blister gas burns affecting this area.

(2) The most common type of burn affecting the male genitalia is a diffuse vapor burn. Erythema is not conspicuous on account of the normal pigmentation of the penis and scrotum. The most prominent objective feature of the burn is edema which involves the penis and scrotum. Edema fluid accumulates most readily at the prepuce, which becomes markly distended in its entire circumference and forms a characteristic semitranslucent ring around the corona. (See fig. 31 and 32.) In more severe cases the skin covering the entire body of the penis becomes grossly edematous, the external aperture being constricted to pinpoint size. (See fig. 33.)

(3) Lesions of this type give rise to greater mental apprehension than physical discomfort although the latter can be considerable. Occasionally, vesication is superimposed on the edematous skin of the penis. Small blisters or ulcers due to a break-down of the skin are not infreuent at the tip of the prepuce, where they are likely to become secondarily infected and retard healing. With the severe cases associated with marked edema, retention of urine may occur, partly mechanical and partly reflex nerve in origin.

(4) In mild cases objective changes on the scrotum tend to pass undetected because of the normal pigmentation and the elasticity and looseness of the skin. Edema may be present before sufficient fluid accumulates to reveal its presence. In severe cases the scrotum may become grossly enlarged. The tissues in this region are predisposed to edema due to the large amount of subcutaneous tissue, laxity of the skin, and the dependent position of the organs. The rugae may be partially or completely obliterated. (See fig. 33.) Pinpoint vesication may be present. Usually a delay of a few days elapses before it appears. The skin of the scrotum tends to break down easily, revealing small painful ulcers and fissures.

(5) Burning is the most prominent subjective symptom of lesions of the genitalia. It increases in intensity as the condition develops. Mental apprehension, anxiety and distress prevail while the objective changes described above are present. As the edema decreases, itching commences and may persist long after the active effects have subsided. Sometimes itching is intolerable. The skin of the scrotum tends to break down for a considerable period after the lesions have healed, with raw cracks and ulcers which are painful and irritating.

(6) A characteristic feature of the genital region, after exposure to low dosages of blister gas, is the delay in the development of the symptoms, frequently 4 to 10 days elapsing before the earliest evidence appears.

(7) Mild cases without edema or vesication, complaining only of subjective irritation and burning may be safely returned to the line.

Some form of anti-irritant lotion is advisable. In disposing of mild cases of blister gas burns of the genitalia, the medical officer must assure himself as best he can that the symptoms are not in an early stage of development that will mature within a day or so to a severe degree of vesication and edema. This will depend upon the circumstances of the exposure, the interval following exposure, and the severity of the associated lesions. Severe cases as described above should be evacuated as casualties, not only because of the physical discomfort involved, but also because of the marked mental apprehension from which the individual may suffer.

G. Systemic Effects

(1) In general it may be considered as probable that severe systemic effects due to the blister gases will be encountered only in the pres-

Figure 32. CASUALTY

The appearance of the penis 48 hours after exposure to a moderate dosage of mustard vapor is shown in this photograph. Edema had distended the prepuce which formed a translucent ring around the corona.

In addition, edema was present in and beneath the skin of the scrotum. Burning and itching of the parts were reported.

Cases presenting these appearances should be evacuated as casualties.

Figure 33. CASUALTY

This photograph shows the effects of exposure to high dosages of mustard vapor.

There was massive edema of the entire penis sufficient to interfere mechanically with micturition. Vesication was present at the end of the penis. The scrotum was generally edematous with pinpoint vesication. The rugae were partially obliterated.

Lesions of this type call for evacuation to a hospital where treatment for 4 to 6 weeks is usually required.

ence of, or antecedent to, disabling skin lesions. The medical officer should be familiar with these symptoms which include anorexia, nausea, vomiting, depression and fever and are far more prone to be encountered in hot than in temperate climates. Malaise and nausea generally initiate the reaction which may then progress to either mild and transient vomiting or to severe and persistent vomiting and retching. Anorexia may be the only complaint in mild reactions. The usual time of onset for such symptoms is from 4 to 12 hours after exposure and often occurs before skin injury is manifest. No rule can be given for the duration of these symptoms, although men have usually recovered from the severe vomiting within 24 to 36 hours. Anorexia and nausea may persist over a longer period of time.

(2) The temperature may remain elevated for several days. Mental depression may follow mustard burns and persist for several days after exposure.

(3) Since men with systemic reactions will probably be casualties, not only because of these symptoms, but also because of extensive skin burns, such cases should be evacuated without hesitation as soon as facilities permit.

H. Secondary Bacterial Infection in Blister Gas Injuries

(1) This section deals with secondary bacterial infection of blister gas injuries, insofar as it influences the disposition of the affected personnel in forward positions. For the management and treatment of such cases the reader is referred to sec. III.

(2) Secondary bacterial infection has frequently been cited as a common complication of mustard burns of the skin. While these injuries sustained in the field are exposed to the same risk of developing sepsis as are thermal and traumatic wounds, observations made at experimental installations in both temperate and tropical climates have indicated that the incidence of sepsis in mustard lesions has been remarkably low.

(3) When it occurs, secondary infection manifests itself some days after the injury first develops. It is unlikely that in the front lines medical officers will see gross secondary infection of extensive blister gas injuries since these more severe cases will probably have been evacuated prior to the development of infection. Infected lesions of this type will more probably come to the notice of medical officers in rear medical units.

(4) When secondary infection develops in blister gas injuries of noncasualty severity, each case should be judged individually. Infection of small lesions does not compel evacuation. Infection in multiple lesions which previously permitted a man to continue his duties is usually an indication for his evacuation as a casualty, particularly if constitutional effects are associated therewith.

(5) Sites in which sepsis tends to be particularly disabling are the feet and hands, the genitals and the flexures of the limbs.

(6) In injuries to the respiratory tract caused by blister gas vapor, secondary infection, as in cutaneous lesions, is more likely to occur in severe rather than in mild cases. It is unlikely that the medical officer in forward areas will ever encounter such cases. Severe respiratory tract symptoms will invariably be associated with eye effects of casualty severity. Such respiratory lesions as may develop will not appear for several days, by which time, the case will have been evacuated as an eye casualty to a rear medical unit.

(7) Secondary infection is uncommon in mild cases of mustard conjunctivitis which ordinarily would allow an individual to continue in the line.

(8) With eye effects short of casualty significance, respiratory tract effects (pharyngitis, laryngitis and tracheitis) may continue to increase in severity for several days. Cases of this type may rarely develop secondary infection in the form of bronchitis and bronchopneumonia.

14. TREATMENT OF THERMAL BURNS

A. Primary Objectives of Treatment

(1) To protect the burned area, which is an open wound, from further contamination.

(2) To prevent and combat shock as promptly as possible by plasma or albumin transfusion.

(3) To relieve pain.

(4) To minimize fluid loss.

(5) To maintain optimum healing conditions by adequate protein and vitamin intake.

(6) To prevent contracture and excessive scarring by proper splinting and early skin grafting.

B. First-Aid Treatment

(1) *Asepsis:* A burn is initially a sterile wound; therefore, all infection will be introduced from the outside. In the primary treatment of burns, it is essential that the burned area be protected from contact with bacteria. Contamination of the burned surfaces by organisms from the attendant, particularly from his nose and throat, is responsible for most of the more serious infections which subsequently develop. Therefore, to minimize contamination from this source, the medical officer and assistants should be masked, if practicable; otherwise, mouths must be kept closed.

(2) *Morphine:* Pain should be relieved by adequate doses of morphine. Pain resulting from an extensive burn can ordinarily be relieved by a dose of ½-grain (0.032 gram) of morphine. In the presence of circulatory failure, there may be a delay in absorption of morphine administered subcutaneously, the full effect not being manifest before normal circulatory dynamics are restored. Therefore, caution must be exercised to control the dosage intervals, avoiding a cumulative effect which may result in severe morphine intoxication. In the presence of pronounced anoxia, large doses of morphine are dangerous, and under such circumstances, the dose should not exceed ¼ grain (0.016 grams). Syrettes of morphine, ½ grain, are available in the first-aid pouch.

(3) *Chemotherapy:* When indicated, specific antibacterial therapy should be administered. Penicillin is the drug of choice and, if available, should be given intramuscularly in doses of 25,000 units every 3 hours as long as indicated. In addition, 25,000 units should be given intravenously at the time of the first intramuscular dose. In the absence of penicillin, sulfadiazine is given orally with an initial dose of 4 grams. This is contained in the first-aid pouch.

(4) *Prophylaxis against tetanus:* All personnel with burns of the second and third degree shall be given an emergency injection of 0.5 cc. of tetanus toxoid injected intramuscularly, providing they have received initial immunization. Those individuals who have not previously received tetanus toxoid should be given 1500 units of tetanus antitoxin immediately and weekly during the period of healing. This should be preceded by careful skin testing for possible sensitivity to horse serum.

(5) *Shock therapy:* Administer plasma promptly, if available, or the equivalent number of units of human serum albumin, as this is an important element in the treatment of shock. When albumin or plasma are not immediately available, water should be given by mouth.

(6) *Burned area:* Tannic acid and all other tanning agents or escharotics will not be used. Remove rings from fingers of burned hands. Irrespective of its location, cover the burned surface with a liberal amount of sterile petrolatum. The local application of sulfonamides, penicillin, or other anti-bacterial agents is not approved. The burn should then be covered with 1 or 2 layers of sterile fine mesh gauze (44 mesh gauze bandage is satisfactory). Place over this a smooth thick layer of sterile gauze dressing (large or small first-aid dressings are especially suitable for this purpose). Finally, a gauze or muslin bandage should be firmly applied over the dressing. When an extremity is involved, a splint is advised as a final step in the dressing.

C. Definitive Treatment When Patient Arrives Where Hospital Facilities Exist

(1) Combat shock by adequate and prompt administration of plasma or human serum albumin. In the presence of extensive burns, quantities of plasma up to 12 units or more may be required in the first 24 hours. Plasma must be given rapidly to the patient in a critical condition. Syringe injection may be used. After hemoconcentration has been corrected by plasma and fluids, transfusion of fresh whole blood, if available, should be given to combat the rapidly developing severe anemia which follows extensive burns; when anemia exists, whole blood transfusion is particularly indicated as a preliminary to skin grafting.

(2) Parenteral fluid replacement other than that attained by means of plasma or whole blood transfusions should be accomplished by means of 5 percent dextrose in sterile distilled water. The intravenous administration of sodium chloride solution should be reserved for those burn cases in which mineral depletion occurs, such as that resulting from persistent vomiting.

(3) Minimize pain by adequate doses of morphine.

(4) The principal of infrequent dressings should be followed. A properly applied initial dressing may be left in place for 10 to 14 days. If redressing is indicated the burned area will be treated as follows, using standard operating room technic with patients and attendants fully masked.

(a) *Cleansing:* In cases in which the burned surface appears clean, no further preparation should be done. It should be reserved for gross soiling. If the burned area is heavily covered with fuel oil, the excess may be removed by gently swabing the area with cotton and a suitable detergent, sterile lard or liquid petrolatum. Cleanse separately and carefully the surrounding skin for a considerable distance with white soap and water. This must be done with a minimum of trauma. Do not use brushes in the cleansing of the burn, and avoid applying tincture of green soap.

(b) *Minimal debridement:* Loose shreds of epidermis should be carefully removed with sterile forceps and scissors, and saved for bacteriologic study, if feasible. Small blisters should not be disturbed, but larger ones may be punctured without the removal of the epidermis. Evidence of irreparable damage to deeper layers of skin may not be apparent for several days, and excision in such cases should not be done until it is certain that the tissue is dead. The resulting wound should be handled as any other open surgical wound, primary grafting of the skin being carried out as soon as conditions permit. General anaesthesia should be avoided if possible, and morphine used to alleviate pain during cleansing, debridement and application of dressings. Pentothal, if needed, should be used in analgesic and not in anesthetic dosage. Local anesthesia is contraindicated.

(c) *Dressing of the burned area:* Tannic acid and all other escharotics shall not be employed in the treatment of burns. Cover the burned area with sterile petrolatum. Strips of a fine mesh sterile gauze (44 mesh gauze bandage is satisfactory) should be applied. Over this should be added a smooth, thick layer of sterile dressing; this may consist of gauze, absorbent cotton, cotton waste, or cellulose. The dressings should be held in place by an evenly and firmly applied bandage; stockinette or some form of elastic bandage is more effective than the ordinary roller bandage. Portions of an extremity distal to the burn should be incorporated within the pressure dressing. The margin of safety between effective pressure and excessive compression is relatively small. All dressings should extend well beyond the burned area. Adjacent burned surfaces on fingers and toes should be separated by vaseline gauze and thin dressings prior to the application of pressure dressings. Uninvolved tips of fingers and toes are left exposed to check for circulation. Immobilization of the part by splinting should be effected when possible.

(5) *Chemotherapy:* Penicillin is to be administered by the systemic route as 25,000 units every 3 hours intramuscularly as long as indicated. Sulfadiazine will be used only if penicillin is not available. Subsequent to the initial first-aid dose it should be given only under the direction of a medical officer. Great care must be exercised in the use of sulfonamides in burned patients because of the danger of renal damage. The presence of such damage due to the burn and extensive loss of fluid from the burned surfaces with resultant decrease in urinary output increase the hazard of renal complications due to sulfonamides. When adequate urinary output (1500 cc.

of urine per day) is obtained, maintenance doses of sulfadiazine of 1 gram every 4 hours should be given. Four grams of sodium bicarbinate should be given with the initial dose of sulfadiazine and 2 grams every 4 hours thereafter to keep the urine alkaline.

(6) Replacement therapy is undertaken as soon as resusitation is assured. Correction of fluid balance, whole blood transfusions and increased dietary protein are part of this program. Plasma remains the agent of choice for treatment of impending or established shock and for correction of the initial hemoconcentration. Blood transfusions are desirable in the later stages of resusitation, especially if there is evidence of red blood cell destruction.

(7) *Skin grafting:* Early epithelization is one of the most important factors in preventing contractures and in obtaining an optimal functional and cosmetic result. For this reason skin should be grafted onto the granulating surfaces as early as possible. Granulating surfaces are prepared for skin grafting by excision of the slough and the application of dry fine mesh gauze under pressure dressing for 3 to 5 days. Systemic penicillin therapy is maintained during this period.

Section XIII

45. THE CARE OF CONTAMINATED CLOTHING AND EQUIPMENT AT MEDICAL INSTALLATIONS

A. Introduction

(1) In the event of gas warfare, due care must be exercised at medical installations to prevent injury to patients and medical attendants from clothing, blankets, or other equipment, contaminated with blister gases. Proper steps must also be taken to obtain timely replacement of items made unusable by contamination, and to insure the salvage and decontamination of such equipment. For more detailed instructions refer to the Defensive Chemical Warfare Manual, FTP 222, United States Fleet.

B. Removal of Contaminated Clothing and Equipment

(1) Clothing and equipment contaminated by blister gas should be removed from the casualty at the earliest practicable moment, with due regard to the general condition of the patient.

C. Disposition of Contaminated Clothing and Blankets

(1) An area out of doors or in a leeward exposed topside position afloat, should be designated as a clothing dump, and contaminated blankets and clothing, except impermeable aprons and rubber gloves, should be transferred to this dump as conditions permit. At shore establishments the dump should be at a safe distance from the medical

installation and living quarters preferably at a minimum of 100 yards, down-wind.

(2) The dump should be clearly marked "Danger, Gas."

(3) Gas casualties should not be admitted to a hospital, sick bay, dressing station or other enclosed spaces unless clothing or blankets known to be contaminated with blister gas have been removed and the patient decontaminated. To do so may result in severe skin burns of other patients and medical personnel by contact with blister gas, liquid or vapor, and in injury of the eyes and respiratory tract from vapors which accumulate in confined spaces. Provision should be made at aid stations, if possible, for well ventilated posts where decontamination can be accomplished without breaking the gastight integrity of the ship or subjecting the shore installation to contamination.

D. Notification of Chemical Warfare Officer

(1) The medical officer should notify the chemical warfare officer advising him that the dump of contaminated clothing and blankets now exists, its exact location, and approximate size.

E. Apron Protective Impermeable

(1) The apron, protective impermeable is intended for use by medical personnel while treating and handling casualties contaminated by blister gas. The apron is always worn in conjunction with complete impregnated protective clothing and impermeable protective rubber gloves. The gas mask is also necessary as a part of the complete protective outfit.

(2) Litter bearers should don the complete outfit described above before moving into dangerously contaminated areas. Prior to handling or treating contaminated patients, the aid station attendants and others should don the complete oufit. The apron should not be removed until the danger of contamination has been removed. If treatment of patients is hampered by the use of the impermeable gloves, such gloves may be removed with comparative safety after removal of all of the casualty's heavily contaminated clothing, and the treatment continued by wearing protective woolen gloves. Contaminated aprons may be worn with safety for many hours in conjunction with impregnated protective clothing. Aprons, however, should be decontaminated after each day of wear, as prolonged contact with the liquid blister gases may have a deleterious effect on the coated fabric. The complete outfit should also be worn while decontaminating litters, ambulances, and other equipment contaminated in transporting casualties.

(3) Before donning the apron, impregnated protective clothing is inspected to insure that a protective gas seal is secured. Imperme-

able gloves are put on prior to handling contaminated patients or material.

(4) In removing the apron, the procedure is as follows: After removal of the impermeable gloves, the neck strap is unbuttoned with the left hand and the apron permitted to fall freely from the body. Care should be exercised in the removal of the apron so that contaminated surfaces of the apron are not permitted to come into contact with the clothing of the wearer or other individuals. Decontamination procedure should be applied as soon as practicable to contaminated articles of clothing and equipment.

F. Disposition of Contaminated Gloves and Aprons

(1) It will not be possible ordinarily for aid stations to decontaminate aprons and rubber gloves during combat operations. Thus, gloves and aprons of aid stations which become contaminated during combat should be placed in a gas tight container to await decontamination. If this is not possible the items must be discarded.

(2) Medical units are ordinarily responsible for decontaminating their own impermeable aprons and gloves, although this may not be possible at all times.

G. Decontamination of Blankets and Impregnated Protective Clothing

(1) Contaminated blankets and impregnated protective clothing removed from casualties are removed from the clothing dump by direction of the chemical warfare officer and decontaminated under his supervision. Methods of decontaminating blankets and protective clothing are described in the Defensive Chemical Warfare Manual, FTP 222, United States Fleet.

H. Decontamination of Aprons

Impermeable aprons may be decontaminated by one of the following methods:

Method I: Immerse the apron in water at a temperature just below boiling for a period of 1 hour. Remove and pull apart all surfaces which are stuck together. Then dry in air and return apron to service.

Method II: In an emergency, small areas of the apron may be decontaminated with protective ointment, S-461 or S-330 or, in the case of arsenicals, BAL ointment. It should be rubbed into the surface, allowed to remain 15 minutes and then removed.

I. Decontamination of Impermeable Rubber Gloves

The decontamination of impermeable rubber gloves must be done carefully to prevent severe chemical burns while using them. The following method may be used:

Method: Immerse the gloves in boiling water for 2 hours, dry and return to service. In immersing the gloves, care must be taken that the gloves are filled with the solution and that they are kept below the surface.

J. Decontamination of Gas Masks, Canvas, and Leather Equipment

(1) *Gas masks:* Gas masks that have been grossly contaminated with liquid blister gases should be discarded. Masks that have been exposed to droplets or vapor may be decontaminated as follows:

(a) The only completely effective method of decontaminating the rubber parts of the gas mask is to soak them in hot water (just below the boiling point) for 3 hours. This process, however, requires that the mask be completely disassembled and should be attempted *only in an emergency.*

(b) The facepiece can be decontaminated by the use of protective ointment, S-461 or S-330 or BAL ointment. The facepiece is just blotted dry from liquid contamination and coated (except the eyepieces). The facepiece is treated with the proper ointment which is allowed to remain for 15 minutes and then removed carefully. To be most effective, ointment must be applied within 3 minutes after contamination. Eyepieces should be blotted dry and then washed with soap and water. Do not apply ointment to the eyepieces as it will etch them severely. The hose can also be treated with ointment if applied to the outside *immediately* after contamination. Blister gas absorbed by the hose will produce vapor inside the facepiece.

(c) Two or 3 weeks aeration at moderate temperature is required to decontaminate masks heavily contaminated by vapor concentration or droplets. In cold weather longer periods are required.

(d) If a metal canister becomes contaminated with liquid blister gas, it should be wiped dry and decontaminated with RH-195 (DANC), soap and water or protective ointment or BAL ointment. If liquid blister gas has entered the canister, it must be replaced.

(2) Gas mask carriers, first-aid pouches, and canvas equipment may be decontaminated by soaking in water, to which 2 ounces of sodium carbonate (washing soda) per 10 gallons of water have been added, for 1 hour at a temperature just below the boiling point. The items are then hung up to dry and returned to service.

(3) Shoes, straps, and other leather equipment may be decontaminated by soaking in water heated to a temperature of about 122° to 131° F. (about as hot as the hand can stand), for 4 hours, then dried and returned to service. Use approximately 1 gallon of water per pound of leather equipment.

K. Care of Litters

(1) *Protection:* Emergency protection of litters may be accomplished by covering the litter with blister gas resistant materials such as the cover, protective, individual or the sack, gas resistant. The latter is supplied only to the Marine Corps.

(2) *Decontamination of litters:* If possible, litters should be disassembled and components decontaminated as follows:

(a) *Canvas:* Litter canvas may be decontaminated by immersion in boiling water for 30 to 60 minutes. If available, 2 ounces of washing soda (sodium bicarbonate) to each 10 gallons of water is recommended. An alternative decontamination procedure is to spray canvas with RH-195 (DANC) on both sides. Repeat 2 or 3 times and allow each application of RH-195 (DANC) to dry. Subsequent washing with soap and water is necessary.

(b) *Wood:* A 30 percent aqueous slurry of bleach powder is applied and allowed to react for 6 to 24 hours. Applications are repeated if necessary; the wood is then swabbed dry and allowed to aerate at elevated temperatures if possible. An aqueous slurry of bleach powder is 5 parts bleach to 4 parts water by volume.

(c) *Metal* (unpainted): Decontamination is accomplished by swabbing or spraying with RH-195 (DANC) (issued by BuShips not by BuMed) or available solvents such as gasoline, kerosene, etc., washed with soap and water and finally dryed with rags and aerated for several hours.

(3) If the litter cannot be disassembled or conditions do not permit disassembly, the litter should be sprayed with RH-195 (DANC) several times, allowing each application to dry; visible liquid contamination should be rubbed off and the litter should be allowed to aerate as long as conditions permit.

Section XIV

46. DISINFECTION OF GAS MASKS

Whenever masks are stored, exchanged, or used by more than one individual for training purposes; or when the wearer has been suffering from a cold or sore throat, they should be thoroughly disinfected.

The Navy has available on its supply table approved disinfectants for this purpose under BuMed stock Nos. 1-851 and S1-4790. They are effective germicides and fungicides. Their main advantages are that they do not damage the gas mask and they allow wearing of the mask within 30 minutes. Directions for their use are as follows:

(a) Dilutions shall be made as specified on the container.

(b) In disinfecting the mask keep the facepiece lower than the hose and canister to prevent the disinfectant from running into them. Hold the facepiece in the hand, saturate a small piece of clean rag with the disinfectant, and sponge the entire surface of the facepiece, including the outer and inner sides of the deflector. In this operation do not turn the facepiece inside out. Then apply the disinfectant similarly to the outside of the outlet valve.

(c) Squeeze a few drops of the disinfectant from the rag into the exit passage to the outlet valve. Press the sides of the outlet valve with the thumb and finger to let the disinfectant run out. Do not shake off the excess.

(d) Disinfect also the inner surface of the diaphragm attachment on special type masks. Excessive wetting of the internal parts of these attachments

must be avoided by keeping them above the general level of the area being treated.

(e) Allow all disinfected parts to remain moist for about 15 minutes and then wipe out the inside of the facepiece with a clean dry rag. The mask should dry thoroughly in the air (usually 30 minutes) before it is returned to the carrier.

If approved disinfectants are not available, ordinary soap and water may be used, providing the mask is thoroughly dried before stowage.

There are objections to the use of formaldehyde, cresol, lysol, Dakin's solution, hydrogen peroxide, copper sulfate, alcohol and other disinfectants. They either destroy the mask, have a low antiseptic value, persist for a long time necessitating many hours for airing and ventilation, or they irritate the skin and breathing passages.

Section XV

47. CHEMICAL AGENT CONTAMINATION OF FOOD

A. General

(1) The medical officer is charged with the responsibility to pass upon the edibility of food under conditions of known or suspected contamination with chemical warfare agents.

(2) Contamination of foodstuffs, by chemical warfare agents may occur from contact with vapor, sprays, splashes of liquid, or solid chemicals. Unprotected foods may be so contaminated that their ingestion will produce gastrointestinal irritation or systemic poisoning. The vesicants and arsenicals are the most dangerous in that respect.

(3) Food supplies in storage are not likely to be seriously contaminated if reasonable precautions are taken to protect them against chemical attack. For this reason, large supplies of food should not be condemned en masse simply because they have been exposed to the possibility of chemical contamination. A prompt and careful survey of the supplies may reveal that only a few items have been so seriously contaminated as to require special treatment. Prompt segregation of the heavily contaminated portions will prevent or minimize contamination of the remainder. Generally, foods not especially packed in protective packages constitute the major difficulty. The availability of fresh supplies and available means of decontamination will dictate whether or not reclamation of these contaminated items is worth while. The Bureau of Supplies and Accounts of the Navy and the Marine Corps quarter master present methods of packing foods for overseas shipment greatly minimizing the danger of contamination.

B. Susceptibility to Contamination

The vesicants and chlorpicrin are readily soluble in fats. They will be absorbed by foods of high fat content, and because of diffusion throughout the material, it may be impossible to remove them. Coagulation of protein by agents such as the arsenical vesicants which are acidic or acid-forming may limit diffusion of the agent in high protein foods. Hydrolysis of acid-forming gases in foods of high water content causes decomposition products which render the food unpalatable. Foods of low water and fat content will be relatively less easily contaminated by chemical agents and less difficult to decontaminate. Mustard gas used by the enemy may contain considerable quantities of an arsenical agent, and this fact should be kept in mind.

C. Protection Afforded by Wrapping Materials

In determining the disposition of packaged and stored supplies which have been contaminated, consideration must be given to the nature of the contaminate as well as to the type of foodstuff and the security afforded by the packaging material. Some of these factors are outlined as follows:

(1) Airtight bottles and sealed tins give complete protection against vapor and liquid.

(2) Wooden barrels, well sealed for the exclusion of air, give complete protection against vapor and moderate amounts of liquid.

(3) Wooden boxes, not sealed for the exclusion of air, give little protection against vapor or liquid.

(4) Waxed paper boxes, well sealed for the exclusion of air, give good protection against vapor and fair protection against liquid.

(5) Paper wrapping gives poor protection against vapor and very little against liquid.

(6) Foil and cellophane wrapings, sealed for the exclusion of air, give good protection against vapor and liquid.

(7) Ordinary textiles in a single layer packaging give practically no protection against vapor and liquid.

(8) Coverings of sod and earth give good protection against vapor and liquid.

(9) Open shelters give protection against liquid sprays and splashes. Closed buildings give protection against both vapors and liquids.

(10) Generally, double layers greatly increase the protective efficiency of packaging materials.

D. Storage of Food Supplies

When it is necessary to store bulk food supplies which are poorly protected by packaging, measures should be instituted to make the storage space as gasproof as possible. The most vulnerable food

should be placed in the least exposed positions, keeping in mind the fact that the vapors of chemical warfare agents are heavier than air and tend to accumulate in low places. In the field, tarpaulins covering food supplies give fairly good protection against vapor and liquid agents.

E. Reclamation of Contaminated Supplies

(1) *General:* Food supplies which have become contaminated should be handled only by those trained in decontamination methods and equipped with protective clothing and gas masks. Before undertaking any decontamination procedures, a careful survey should be made to determine the extent of contamination. From information gained on this survey, the exposed items should be divided into three groups for separate treatment as described below.

(2) *Group I:* Will consist of packaged items which have been exposed only to the vapors of the agent. A consideration of the factors outlined in par. C above will serve as a basis for the evaluation of the seriousness of contamination. Generally, the items in this group will be safe to issue to troops after a brief period of airing to remove clinging vapors.

(3) *Group II:* Will consist of packaged items the outside of which have been contaminated with the liquid agent. Attempts to decontaminate porous packaging materials such as cardboard or wood are likely to be unsuccessful and may actually result in spreading the contamination. The correct procedure in handling such items is to strip off the outer contaminated wrapping and examine the inner layer to see if penetration of the agent has occurred. If it has, continue stripping off layers until an uncontaminated layer is reached. Items packed by Bureau Supplies and Accounts and Marine Corps Quartermaster are usually packaged in boxes within boxes so such a procedure is feasible. When an inner uncontaminated package is reached, it should be placed in group I. If the agent has penetrated to the food itself, place in group III. Canned goods may be decontaminated by any of the usual chemical methods such as bleach slurry or decontaminating agent noncorrosive (DANC) RH-195, followed by washing in water.

(4) *Group III:* Will consist of unpackaged or poorly packaged items which have been exposed to the gaseous or liquid agent. The general decontamination procedure to be followed in order is trimming of surface fat and grossly contaminated areas; washing with water or 2 percent sodium bicarbonate solution; and boiling in water. Boiling in water may be eliminated when the contamination has been only with the vapors of the lung irritants or lacrimators. When such an exposure has been light, aeration for a short time may be used for decontamination. Frying, roasting, or broiling will not remove

traces of vesicants from meats. In general, salvage of foods heavily contaminated with droplets of the vesicants, especially the arsenical vesicants, is not practicable. More detailed directions are given below.

(5) *Lung irritants:* This group of agents offers relatively little danger to food products. With the exception of chlorpicrin, these decompose rapidly upon contact with the water in foods, to form comparatively harmless compounds which may alter the flavor. Decontamination can be accomplished by washing, supplemented, where possible, by aeration. Chlorpicrin is slightly soluble in water, and is soluble in fat and most organic solvents. Its removal from foods of low water and fat content can be accomplished by aeration.

(6) *Lacrimators and irritant smokes:*

(a) Large stocks of supplies, when protected by covers or packages, probably cannot be contaminated with a sufficient quantity of the lacrimators or irritant smokes to warrant their destruction. These agents are not easily decomposed by hydrolysis and it would be difficult to reclaim foods *heavily* contaminated by them.

(b) Dry provisions contaminated by lacrimators can be decontaminated by aeration.

(7) *Vesicants:*

(a) When contaminated with *liquid* mustard or a *liquid* nitrogen mustard, foods of high water or fat content are unfit for consumption and reclamation is not practical. When foods have been exposed to vesicant vapor, they can be reclaimed by washing with soda solutions and rinsing with clear water, intensive cooking, or in the case of dry provisions, by 24 to 48 hours aeration. Lean meat can be reclaimed by boiling in water for ½-hour or more, or in the case of the nitrogen mustards, with a 2 percent solution of baking soda. The water must be discarded after boiling.

(b) Lewisite, ethyldichlorarsine, and phenyldichlorarsine readily hydrolyze to poisonous arsenical oxides. Foods contaminated with these agents cannot be reclaimed.

(8) *Screening smokes:*

(a) HC, FM, FS, and WP smokes are usually nontoxic. They may alter the taste of foods by acid produced on contact with moisture, but do no damage otherwise.

(b) Liquid FM (titanium tetrachloride) can be washed from foods. Liquid FS (sulfur trioxide-chlorosulfonic acid solution) is highly corrosive and forms strong acids on contact with moisture. It may render unfit for use foods which cannot be washed readily. After trimming, washing, or cooking, if the food does not taste too acid, it is safe to use.

(c) Unburned particles of white phosphorus are poisonous and must be removed from foods. Fats and oils may dissolve poisonous amounts of the agent and should be discarded.

(9) *Other agents:* Carbon monoxide, arsine, and hydrocyanic acid will have little effect upon food supplies. Hydrocyanic acid is water soluble and foods with high water content may become unfit for consumption after exposure to high concentrations of that agent. The effect of cyanogen chloride on foods is not known. As a pre-

caution, foods exposed to the vapors of this material should be considered toxic.

(10) *Meat from gassed animals:* It may be necessary to use animals for food after they have been exposed to liquid splashes of chemical warfare agents. Economics may justify the early slaughter of exposed animals *before the effect of such exposure is shown.* If such animals are slaughtered in the preliminary stages of poisoning and all tissues exposed to the gas (lungs, local areas) are discarded, there is no objection to the consumption of the meat, provided the animal passes an otherwise satisfactory meat inspection. This is true even of animals poisoned by arsenical agents, since the edible tissue will contain amounts of arsenic too small to be toxic. Organs such as the liver, brain, heart, kidney, and lungs will contain relatively more arsenic than the musculature, and should be discarded. The meat should be well cooked.

Section XVI

48. DETECTION OF CONTAMINATED WATER AND ITS PURIFICATION

A. General

The medical officer is charged with the responsibility to pass upon the potability of water. It therefore follows that the testing of water for the presence of chemical warfare agents falls under his cognizance. Methods for detecting chemical agents make it possible to determine safe and unsafe water. Decontamination of water is not a function of the medical department but is under the cognizance of the group responsible for the procurement and treatment of water supply. Contamination of the water supply is to be expected in areas subjected to attack with chemical warfare agents. This contamination may reach harassing or toxic concentrations and, if undetected, can produce a large number of casualties. The presence of dangerous amounts of chemical warfare agents in water can be determined by special methods of analysis. Transportation of water may be required. Purification should be resorted to only in extreme emergency.

(1) *Caution:* Even when chemical tests fail to detect the presence of chemical warfare agents, water obtained from sources known to be, or suspected of being contaminated must not be consumed in amounts greater than 2 or 3 swallows at a time and not more than 3 canteenfuls during the first 24 hours after contamination. To guard against cumulative effects, this water should not be used for periods exceeding 1 week.

(2) *Important agents:* The vesicants and the systemic poisons, cyanogen chloride and hydrogen cyanide, are the agents most likely to cause casualties when introduced into water. It is considered improbable that toxic concentrations of heavy metals and alkaloids will be encountered.

B. Toxic Limits

The toxic limit for lewisite (L) is 20 ppm. (20 mg/l), (10 ppm. (10 mg/l) as As_2O_3), provided the water is chlorinated by the standard procedure for bacterial purification and is used for not more than 1 week in order to avoid cumulative effects. Unhydrolized nitrogen mustards (HN) in concentrations of 10 ppm. (10 mg/l) have produced vomiting in man when consumed in 200 cc.-quantities at a time but have not caused actual casualties. In higher concentrations they are extremely toxic. Mustard (H) dissolves slowly in water but may be found floating in tiny globules, as a film on the surface or collected in pools on the bottom. Small droplets when fed with water to rats have produced perforating ulcers in the intestinal tract. The limits for cyanogen chloride (CK) and cyanide (AC) are 25 ppm. (25 mg/l).

C. Reactions with Water

The three vesicants, lewisite, mustard, and nitrogen mustards, all react with water to form hydrochloric acid and the hydrolysis product corresponding to the agent. Lewisite reacts with water practically instantaneously, forming the hydrolysis product lewisite oxide, which is toxic and somewhat vesicant. Mustard (H) reacts with water to form the nontoxic thiodiglycol. A solution containing 100 ppm. (100 mg/l) mustard becomes nontoxic at the end of 1 hour. Some types of mustard contain a highly odorous compound which renders the water nonpalatable even after hydrolysis. Nitrogen mustards hydrolyze slowly to a nontoxic product. A solution containing 100 ppm. may remain toxic for 4 to 6 days. Cyanogen chloride is soluble in water to the extent of 6 to 7 percent by weight at one atmosphere pressure and 25 degrees C. This compound hydrolyzes slowly in water forming cyanates which readily decompose into harmless products. A concentration of 50 ppm. will be hydrolyzed to 25 ppm. in about 1 week. Hydrocyanic acid and many of the cyanide salts are very soluble in water and do not react appreciably with it.

D. Detection

(1) *Kit, water testing, screening, for detection of chemical warfare agents:* Stock No. S13–461, adopted by the Bureau of Medicine and Surgery affords simple rapid field tests of water to detect dangerous chemical contaminations. In combat it may be impracticable, or

impossible, to obtain water from water supply points. If it becomes necessary to use other water, the medical officer will be responsible for determining the potability of water procured for the personnel of his unit. Under such circumstances, the kit, water testing, screening should be employed by the medical officer. Tests should be made of the raw water, prior to chlorination. If this is found to be free of contamination, it may be used *after the usual purificiation by chlorination to render it safe from bacterial pollution.*

(2) *General:* Description of water testing kit. For the sake of simplicity, analytical procedures have been developed to employ dry reagents which are furnished as tablets or pellets of proper size. Except for warming with the hand in some of the tests, no heat is required. The kit contains equipment for testing 15 samples of water. The reagents and equipment are packed in a pocket-sized container, approximately 5½ by 3¾ by 1¾ inches, divided into 10 compartments. The container is constructed of transparent plastic. The kit contains 2 test tubes, a chlorine demand assembly, a bottle and tube for the detection of arsenicals by a modified Gutzeit method, and 7 vials containing reagents and test papers. The vials are identified by letters printed on the paper liners. Their caps are made of colored plastic matching the color of the paper liners. A test tube brush and pipe cleaner are provided for cleaning the apparatus.

(3) *Purpose:*

(a) The field kit for testing water is designed for reconnaissance. It is employed to screen out sources of water so contaminated that they cannot be rendered potable by customary field methods, such as chlorination in the Lyster bag. Individuals performing the tests must have normal color vision.

(b) Negative tests indicate that the water is suitable for chlorination and may be used by personnel within the limitations.

(c) If any of the tests are positive, the water should not be used until a more complete analysis can be made.

(d) The main purpose of the kit is to detect contamination of raw water. It is not designed for use on treated water as the chemical reactions of water treatment invalidate the interpretations.

(4) *Analytical procedures:* A booklet issued with the kit gives specific directions for each test. Nontechnical language is used and the reagents are referred to by the letters on the vials. Briefly, the tests involve the following chemical processes:

(a) Arsenicals are converted to arsines through the action of hydrogen, produced by the action of sodium acid sulfate on zinc. The arsine reacts with a sensitized paper to produce a stain. This is sensitive to 5 ppm.

(b) pH is determined by indicator paper.

(c)) Mustards are detected by means of the DB3 reagent, 5 ppm. (5 mg/I) of unhydrolyzed nitrogen mustard and 15 ppm of unhydrolyzed sulfur mustard can be detected. Cyanogen chloride produces a yellow color with the DB3 reagent.

(d) The chlorine demand or chlorine uptake is determined by means of

halazone tablets and an orthotolidine testing assembly. This test detects the presence of other agents, such as the cyanides, not specifically tested for.

(e) If no evidence of contamination is found, odor and taste can be tried with safety.

(5) *Interpretations:*

Test	*Indication of positive results*
Arsenicals	¼-inch stain on test paper.
pH	Below 6 when compared with color standards.
Mustards	Any blue or red color no matter how faint and transitory.
Chlorine Demand	No color in solution or color lighter than that of band in plastic tube.
Taste and Odor	A lacrimating or chlorinous odor, a biting and/or peppery chlorinous taste, any taste or odor of a known war gas.

If one or more of the above tests gives a positive result, the water will be considered contaminated.

(6) *Limitations:*

(a) If the tests are carefully performed, the threat of serious casualties from contamination of the water with known agents will be avoided.

(b) The tests provided by the kit will not screen out traces which are harmless when the water is used for short periods of time. When arsenic is detected, even though the water is passed as safe by the kit (that is, an arsenic content which gives a stain shorter than ¼-inch on the test paper), the water should be used for drinking and cooking purposes not to exceed *1 week*, because of possible cumulative effects.

(c) Water may give a negative test for nitrogen mustards and still give symptoms if consumed in large quantities. Hence the water should not be used without special purification even if the faintest blue color develops in the test for mustards.

(d) The tests provided by the kit are not quantitative, and will therefore serve as a guide for the purification of field water supplies only within the limitation specified.

E. Action Required if Water is Found to be Contaminated by Chemical Agents

Whenever positive tests are obtained with the kit, water testing, screening, the water will be considered contaminated and the following actions taken:

(1) The commanding officer will be notified that the water source is contaminated and is unfit for drinking purposes.

(2) The commanding officer will establish the necessary safeguards to prevent personnel from drinking the contaminated water.

(3) An alternative source of uncontaminated water should be sought and, if found, should be employed.

(4) If a source of uncontaminated water cannot be found, consideration should be given to moving to a different location, or to importing purified water to the area.

(5) In any event, the contaminated water should not be used by men until it is purified and then only after every effort has been made to obtain an uncontaminated supply.

(6) Contamination discovered in otherwise suitable water should be reported as promptly as possible to the commanding officer, so that the matter can be brought to the attention of the officer responsible for purification.

F. Scale for Issue of Water Testing Kits

As the kit is expendable the individual items of its contents are not supplied for refilling. When the contents have become exhausted, the complete kit can be replaced through the usual channels of medical supply.

G. Use of Suspected Water

(1) Water suspected of being contaminated but giving negative tests with the water testing kit, screening can be used sparingly, after chlorination, for periods not to exceed 1 week.

(2) When suspected water is used, great care should be taken not to stir up material from the bottom as it may contain chemical agents when the water above does not.

H. Procedure in Case of Heavy Contamination

When water is too heavily contaminated to pass the screen kit test, every effort should be made to secure another source or to have pure water supplied from elsewhere. If pure water is not available, treat the contaminated water as outlined briefly below. Only trained personnel should undertake such procedures.

I. Purification of Contaminated Water

(1) Water must be withdrawn from the intermediate levels with minimum disturbance of the surface and no disturbance of the bottom.

(2) Treatment of large volumes:

(a) The contaminated water is pumped into a canvas reservoir and a quantitative analysis made by the responsible officer.

(b) It is then treated with activated carbon (200 mesh) in the following doses.

1 For lewisite, 30 ppm. (30 mg/l) carbon for each ppm. (mg/l) lewisite.

2 For mustard, 30 ppm. (30 mg/l) carbon for each ppm. (mg/l) mustard.

3 For nitrogen mustard, 60 ppm. (60 mg/l) carbon for each ppm. (mg/l) nitrogen mustard.

(c) The carbon and water are mixed for 20 minutes to insure complete absorption of the agent by the carbon.

(d) 175 ppm. (175 mg/l) of coagulant is added to the carbon-dosed water together with sufficient alkali to give optimal coagulation.

(e) After thorough, gentle mixing the water is allowed to coagulate and clarify by sedimentation for 30 minutes.

(f) The supernatant water is filtered through the portable water purification unit, at normal rate of 10 gpm. or preferably more slowly.

(g) The filtered water must be tested quantitatively to see that it meets the following requirements:

(1) Mustards, not more than 2 ppm. (2/mg/l).
(2) Lewisite (arsenicals), not more than 20 ppm. (20 mg/1).
(3) pH above 5.
(4) Chlorine demand, less than 5.
(5) No chemical odor or taste.

J. Treatment in Lyster Bags

(1) When the portable water purification unit is not available, small volumes can be purified by using two Lyster bags.

(2) If testing equipment is available to identify the contaminating agents and determine their concentrations, add activated carbon in the dosages given in paragraph I (2) above to the water in one Lyster bag. If the identities and concentrations of contaminations are unknown, add 2 pounds of activated carbon.

(3) Stir for 20 minutes.

(4) Add 1 ounce of alum and sufficient alkali to give optimal coagulation. These chemicals should be dissolved separately in small volumes of water prior to their addition to the Lyster bag.

(5) After thorough, gentle mixing, allow to coagulate and clarify by sedimentation for 30 minutes.

(6) Siphon the supernatant water to another Lyster bag (preferably through a filter).

(7) After testing to insure that the requirements of I (2) (g) above are met, the water in the second Lyster bag must be chlorinated.

K. Chlorination of Contaminated Water

Chlorine reacts with some of the chemical agents making it difficult to remove them by the activated carbon and alum treatment. Therefore, chlorination should be carried out only after filtration through the portable purification unit, and the chlorine feed-line must be connected to the effluent pipe from the filter. In the case of treatment in the Lyster bag, chlorine is added in the *second* Lyster bag. When contamination is suspected, no chlorinating compounds should be added until the water has been clarified.

Decontamination is not a function of the medical department but is under the cognizance of the group responsible for the procurement and treatment of water supplies.

MANAGEMENT AND TRANSPORT OF CHEMICAL WARFARE CASUALTIES IN NAVY AND MARINE CORPS FORCES

49. GENERAL

A. Introduction

(1) Casualties unable to apply self-aid are cared for by the medical service. A casualty is defined as one who is no longer able to carry out his military duties as a result of injury by gas or other weapons.

(2) Noncasualties who are contaminated by blister gas are charged with the responsibility of self-aid or personal decontamination at the earliest possible moment consistent with the tactical situation.

(3) The management and transport of contaminated gas casualties, whether wounded or otherwise, are governed primarily by military considerations.

(4) To facilitate the management and transport of gas casualties, whether afloat or ashore, the medical officer shall develop a plan applicable to the command to which he is attached. This program shall be incorporated in the gas defense bill of that unit. Certain improvisions may be necessary in order to activate such a program. The basic principles of management and transport must be clearly understood and applied in order to make it effective.

(5) The most complicated problems of management and transport concern casualties contaminated with blister gas.

B. The Collection of Casualties

(1) The employment of chemicals in warfare would add greatly to the difficulties of the medical service.

(2) The evacuating medical facilities are concerned only with casualties and personnel no longer qualified to continue their military duties. Other men shall not be sent to the medical service.

(3) The medical service is not the decontaminating facility for personnel of the Navy or Marine Corps who have not become casualties. It is the responsibility of each officer and man to carry out personal decontamination or self-aid at the earliest moment.

(4) There are four outstanding phases to be considered:

(a) The management of the casualty himself, so as to minimize the injury which may result from his chemical exposure, without at the same time aggravating the clinical conditions arising from any associated injury from other battle causes.

(b) The protection of stretcher bearers from unnecessary chemical injuries as a result of working in contaminated areas and in handling contaminated wounded.

(c) The avoidance of spreading contamination to other personnel, and in particular, the protection of the interior of ambulances and other enclosed spaces, such as operating rooms, hospital wards and on shipboard.

(d) Protection of the medical facilities so that normal services, unrelated to chemical warfare, can be carried out.

(5) The practical objectives to strive for are:

(a) A single method for collecting all casualties which is as simple and direct as the rather complicated situation will allow.

(b) A practice for effectively meeting the need for early removal of contamination from the casualty without at the same time aggravating the clinical condition associated with his wound.

(c) A system which will avoid spreading contamination to others, especially in preventing the creation of vapor hazard within closed spaces.

(6) Stretcher bearers are responsible for collecting casualties and for giving first-aid treatment to casualties. This requires, in addition to proficiency in general first aid, that they be well trained in the recognition of war gases, have a working knowledge of their effects on the body, understand the correct first aid to render and be aware of special hazards associated with the handling of contaminated wounded.

(7) *Shock:* The primary duties of stretcher bearers are to control hemorrhage and to prevent further shock. With shock or seriously wounded personnel, decontamination may have to be omitted in the field, but every effort to remove contamination as early as possible should be made. The *ambulatory wounded* should receive first aid, followed by decontamination on the spot. *Stretcher cases* should receive essential first aid, early removal of obvious contamination of the skin or of heavy contamination of the clothing, and immediate transfer to a medical aid station.

(8) To avoid spread of contamination, a knowledge of the behavior of blister gas is required. The objective is to prevent the entry of contaminated stretchers, blankets, clothing or other gear into enclosed spaces, and to treat as contaminated any such articles which have been exposed to contamination. The drill for stretcher bearers is planned to provide such protection. The plan for reception of contaminated wounded at medical aid stations and at fixed medical installations likewise aims at avoidance of spreading contamination.

(9) A gas mask shall be worn by the stretcher bearer at all times when blister gas vapor is encountered or its presence suspected. He should be issued the following: protective clothing, protective capes, and ointments.

C. Transportation of Casualties

(1) The gas hazards attending the management and transport of contaminated casualties in operations ashore may be enhanced by the distances involved and by the character of the terrain, foliage and weather. Afloat, the hazards tend to be increased by the limited top-

side space available for decontamination and the limitations imposed by the necessary provisions for gas integrity of the ship.

(2) Ashore, the hazards of transporting gas contaminated casualties by stretcher shall be minimized by using if available, two stretcher covers as follows:

(a) *Stretcher Cover No. 1:*

1. This item is the impermeable cover designated as "Cover, Protective, Individual" issued to advanced base naval and marine corps personnel. Medical officers of advanced naval bases shall take steps to draw the necessary supply of this item from the stock to be maintained by the Bureau of Ships in these areas. If not available from this source, it may be obtained from the equipment of the casualty to be transported or from noncasualty personnel as in the case of the Marine Corps. Medical officers attached to Marine Corps units shall utilize the impermeable protective cover carried in the gas mask carrier of the casualty transported, or from other noncasualty personnel, as the Marine Corps does not maintain a reserve stock for use as stretcher covers. In an emergency, the poncho carried by Marine Corps personnel in combat areas may be utilized.

2. For use on the stretcher, the cover will be split up each side or up one side and across the top.

3. The use of a clean impervious cover with each casualty permits the alternate transport of a wounded, but clean casualty, by the same stretcher since it prevents contamination from the stretcher to the casualty and vice versa.

(b) *Stretcher Cover No. 2:*

1. This cover is an ordinary unimpregnated blanket routinely issued to stretcher bearers.

(c) If two stretcher covers, Nos. 1 and 2, are used the following procedure shall be carried out:

1. Stretcher cover No. 2 is laid over No. 1 and both are folded over so as to bring the side edges to the center. They are to be folded again and the ends turned in to fit the stretcher when in the carrying position.

2. The prepared stretcher is placed beside the casualty, first aid is administered, the covers are unfolded, the casualty is laid on No. 2 cover and the sides are folded over the casualty and transport begun.

(d) Transport by ambulance or other enclosed vehicle of the contaminated gas casualty cannot be undertaken except with grave risk of contaminating its interior. Casualties must be decontaminated before such transport.

(e) Upon depositing the casualty at the aid station the stretcher covers are to remain with the casualty. Clean covers, if available, previously folded are to be laid into the stretcher for the transport of another casualty.

(3) Afloat, the problems of transport do not warrant the issue of the impervious protective cover. This item is not carried by naval vessels. It is advised that an ordinary blanket be substituted, even though it is pervious to vesicant liquid or vapor. This is preferred rather than leaving the casualty completely exposed. The blanket must be subsequently handled as a contaminated item.

(4) For all activities, it must be emphasized, that if the stretcher is not equipped to limit undue hazards, it becomes contaminated and must be handled as such.

50. EVACUATION OF CASUALTIES SEAWARD FROM SHORE

A. Principles

(1) *Definition of Principles of Seaward Evacuation of Casualties in Chemical Warfare:*

(a) *Evacuation of blister gas contaminated casualties is the same as for other casualties; once personal decontamination has been carried out, clothing and gear removed, and the casualty placed in clean blankets.*

(b) *Contaminated casualties should not be evacuated seaward until they have been cared for in such a manner as to present no risk of contamination of the ship's interior.*

(c) The contaminated casualty, if transferred to a clean blanket after all clothing and gear have been removed, presents little if any risk to the ship. The hazard is further reduced if ointment has been employed in decontamination of exposed skin surfaces, or areas believed to have been otherwise exposed to the liquid agent.

(d) If chemicals have been employed on the beach, or the area being served by the evacuating ships, there are two points in the chain of evacuation at which some measure of protection should be provided against contamination of evacuating ships interior. At both points, the maximum protection possible should be effected as follows:

1. If the evacuating service on the shore carry out paragraphs (b) and (c) above, this is at once accomplished.

2. During the Battalion Landing Team Phase, if chemical attack has been encountered, *in addition to the above*, all ships receiving casualties will have to effect a plan which presupposes that *all casualties* coming aboard are contaminated. *Thus the ship will attempt to protect itself from "Interior Gas Contamination" due to the hasty seaward evacuation of contaminated casualties during this early phase.* This plan will require that all casualties be held on an open deck until they can be changed to clean blankets and stretchers and any clothing not previously removed disposed of. *Not until this has been done* will it be permitted for the casualty to be taken below deck or to enclosed quarters. The same would apply to ambulatory casualties.

(e) The chemical defense bill of the ship shall include a plan for protection against interior gas contamination, and will indicate the disposition of contaminated clothes, gear and blankets topside in the open. The handling of such equipment is carried out by personnel assigned to decontamination squad duties. Ultimate disposition will be effected through representatives of the chemical warfare officer or the marine decontaminating squads in the port to which evacuation is made.

(f) Topside areas or open ventilated areas (See Ch. 2) can be regarded as "dirty" Areas A-B, and enclosed spaces can be regarded as "clean" Areas C-D-E, in accordance with the basic plan attacked. The principle is that all contaminated clothes, blankets and gear be removed in Areas A-B before the casualty is permitted to go to Areas C-D-E.

(g) *Disposition of casualties:*

1. Tear gas and nose gas will rarely produce casualties requiring seaward evacuation.

2. White phosphorus burns require little special attention in this phase but may require seaward evacuation.

3. Lung edema cases, or impending lung edema cases, should not be evacuated seawards.

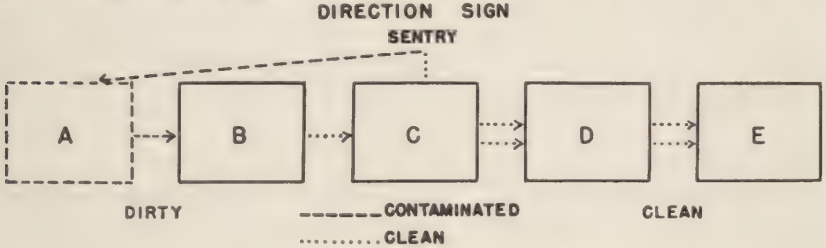
4. If choking gas cases without lung edema are evacuated seaward, they present no special medical problems, except that oxygen may not be available for treatment in the ship phase of evacuating.

(h) The handling of contaminated blankets, clothing and gear, which is held topside, will be specifically covered in such manner as to present least danger of vapor fumes being taken into the ship, and be conducted in such a manner as to provide minimum hazard to those caring for this material, with due regard being paid to the importance of salvage through decontaminating procedures ashore.

(i) The washing of contaminated wounded or other contaminated personnel to remove ointment after personal decontamination is indicated if the military situation permits, and soap and water are available. Shower baths are not suitable for contaminated wounded. Running water or a bucket of water and soap are adequate for contaminated wounded. Water should be lukewarm and not hot. This may be done in enclosed spaces (Areas C-D-E).

CHART 2

BASIC PLAN FOR HANDLING GAS CONTAMINATED WOUNDED AFLOAT



Within the "dirty" area, the following rules will apply:

1. Areas A, B and C need not be adjoining rooms or facilities.

2. Personnel manning the "dirty" area must be trained in the decontamination of casualties and should be provided with impervious protective aprons, and if possible, protective gloves.

3. Free ventilation is required and if possible some cover overhead.

4. The most suitable places for "dirty" Areas A and B are topside on an open deck.

Area A. ***Remove outer clothing, gear and blankets, and place in dirty dump. They must not go beyond this point. Change to clean blanket and stretcher. (This may be done in Area B instead.)***

Area B. ***Situated just forward of entrance to interior. Underclothes are removed and placed in "dirty" dump. Ointment is applied to face, neck and hands if skin is not red; also to any areas suspected of being contaminated. Use BAL ointment for lewisite. Attendants are masked.***

Area C. ***Just inside entrance to interior spaces, reception, records.***

Area D. ***Treatment, additional medical aid when required.***

Area E. ***Awaiting further evacuation.***

B. Application to LCI(L)'s and LST's

(1) Contamination must not be introduced below decks, or inside enclosed spaces.

(2) If chemicals have been used on the beach, or in the area being served by the evacuating ships, all casualties received aboard such ships will be held topside in the open air until clothes and blankets

are removed. They can then be placed on clean blankets and stretchers and with reasonable safety removed to enclosed spaces.

(3) The less the ventilation (small, crowded quarters) the more severe the risks to personnel from interior contamination.

(4) The greater the ventilation (tank deck of LST with blowers going), the less the risks to personnel from interior contamination.

(5) Casualties arriving on LST's via ramp will be taken immediately to the upper deck and held for proper handling.

(6) The functions of basic plan Areas AB shall be carried out topside.

(7) The functions of Areas C-D-E Clean can be carried out at any place inside the entrance from the open deck to the interior of the ship. All such entrances in use may be considered as being the actual boundary line between Area B Dirty and Area C Clean.

(8) In the later phases of a landing operation, no contaminated casualties will be sent to an evacuating ship or small craft. It is only in the early phases when confusion exists that the hazard of interior contamination is liable to present a problem.

(9) On any ship, whether interior contamination may arise from casualties being evacuated, or from direct air attack on the ship, Areas A Clean and B are to be established topside and/or outside. The undressed casualty is then passed to a clean stretcher inside the entrance to the enclosed part of the ship which serves as B-C.

(10) Blowers on the main deck of LST's will reduce vapor hazard there. This deck is more easily decontaminated than are other interior decks.

(11) Contaminated casualties, as a general rule, should NOT be evacuated to small craft, but should be held under cover until personal decontamination can be completed, including removal of all contaminated clothing and gear. Casualties should then be placed in clean blankets.

51. EVACUATION OF CASUALTIES ASHORE IN LAND OPERATIONS

A. Principles

(1) *Avoidance of spread of contamination:*

(a) If gas warfare agents have been used, it must be assumed that all casualties are contaminated until proven otherwise.

(b) If blister gas is encountered attending personnel must wear the gas mask, protective ointment, protective suits, protective gloves, rubber overshoes and an impervious apron. In an emergency the cover protective individual issued to advanced base personnel may be used instead of the impervious apron. *These items, except the mask and protective cover, individual, are contained in the gas casualty treatment case, unit No. 10, Medical Supply Catalog, Item 14-055.*

(c) Personnel handling contaminated casualties shall avoid spreading contamination to other personnel and to facilities not specifically designated for the reception of gas casualties.

(d) Contaminated personnel, casualties, clothing and equipment must be prevented from gaining access to totally enclosed spaces ashore.

(e) Contaminated clothing and equipment shall be placed in tightly covered containers marked for the purpose, or in designated dumps sufficiently far moved from the scene of activities, for decontamination or disposal as determined by the chemical warfare officer.

(f) The spread of contamination to other personnel and to the interior of ambulances and enclosed spaces, such as operating rooms, hospital wards, etc., should be prevented.

(g) Medical facilities must be protected so that normal services, unrelated to chemical casualties, can be carried out.

(2) *First aid:*

(a) A uniform method should be instituted for collecting all casualties which is as simple and expeditious as the complicated situation will allow.

(b) The problem will arise frequently as to which condition requires priority of first aid; the surgical condition or the gas hazard.

(c) In all instances such as severe hemorrhage or shock, the surgical condition takes priority of action.

(d) The casualty should be handled in such a manner as to minimize the injury which may result from his chemical exposure, without at the same time significantly aggravating the clinical conditions arising from the associated injury.

(e) If the surgical condition permits delay, the casualty shall be decontaminated on the spot. Protection from further exposure and, if consistent with battle conditions transported to the nearest aid station designated to receive gas casualties.

B. Decontamination of Wounded

(1) If the situation permits and life is not endangered by the delay, decontamination of wounded men should be carried out on the spot by the litter bearers, or as soon thereafter as possible. This is desirable since the longer the contaminating agent remains on the body, the more severe are the subsequent burns, the greater is the danger of the spread of contamination to equipment, blankets and other personnel.

(2) To complete personal decontamination will prolong exposure and may increase shock. The tactical situation may be such that complete personal decontamination may be impossible. In severe injuries, decontamination will rarely be possible until the immediate surgical condition is attended to, and even then the extent to which it can be done will vary greatly. *Litter casualties* will, as a rule, receive little personal decontamination as their injuries will usually be severe. Most ambulatory casualties will be less severe and should have had personal decontamination. The general principle "*better the blistered living than the decontaminated dead*" should be followed.

(3) In general, the following are considered advisable in the order named:

(a) Essential first aid for wounds.

(b) Care of contaminated eyes.

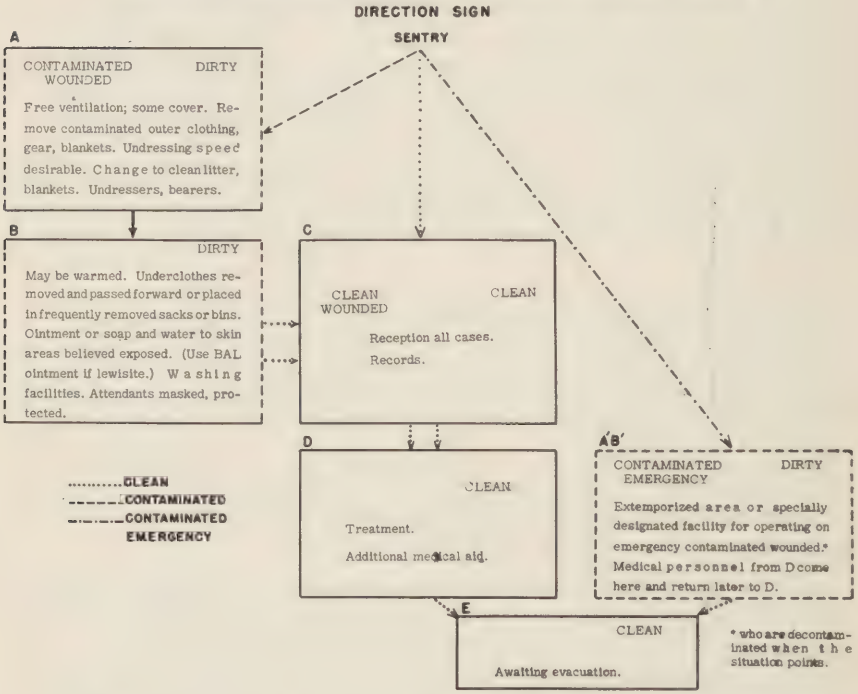
(c) If the casualty is required to remain in the contaminated area or to continue to wear contaminated clothing, mask to protect lungs as soon as rendering of essential first aid permits.

(d) Decontaminate skin as soon as essential first aid and protection for lungs (if required) are provided.

C. Plan for Reception at Forward Areas

(1) For the reception of casualties contaminated with blister gas a "dirty" area is required. In that area contaminated casualties will be decontaminated, and thereafter be passed along with the "clean" cases. A general principle for the sorting and reception of all casualties including chemical, is indicated in chart 3.

CHART 3.
BASIC PLAN FOR HANDLING GAS CONTAMINATED WOUNDED ASHORE



(2) Uncontaminated casualties will be admitted directly to the "clean" area (C) to be treated as ordinary medical casualties. Contaminated casualties will be received into "dirty" area (A), there to be decontaminated before being passed into the normal flow of casualties. If requiring special medical aid before personal decontamination, they are received directly into the "dirty" area (A'B') for

contaminated emergencies, thus by-passing A, B, C and D. Once emergency is cared for in A′B′ the functions of A and B, which are not as yet completed, are carried out before passing the patient into the flow of clean casualties for evacuation (Area E).

(3) Within the "dirty" area, the following will apply:

(a) The arrangements to be made will vary with the location of the unit and the facilities available.

(b) Areas A, B and C need not be adjoining rooms or facilities.

(c) In certain permanent establishments, special provisions may be made. If "cleansing or decontamination centers" have been previously constructed, they should be so adapted as to conform to this basic plan.

(d) In temporary installations an existing hut, tent, or open shelter may be utilized.

(e) In the field the "dirty" area may be only an area marked out and not adjoining, but yet not too far removed from the medical installation. Simple arrangements only are required.

(f) Personnel manning the "dirty" area must be trained in the decontamination of casualties and should be provided with protective aprons, protective gloves, protective ointment, S-461 or S-330 and BAL ointment. (See Defensive Chemical Warfare Manual, FTP 222, United States Fleet.) The Navy individual protective cover can be employed to advantage.

(g) Free ventilation is required, and, if practicable, some cover overhead.

D. Specific

(1) *Area A:* Here all contaminated outer clothing, equipment and blankets are removed. *They must not be taken beyond this point.* Speed in undressing casualties requires practice. The casualty is then changed from a contaminated blanket to a clean litter and a clean blanket.

(2) *Area B:* This area may be warmed. Here under clothing is removed and placed in bins, sacks or piles, which are frequently removed from the area on the assumption that they are contaminated material. In this area the skin is treated with appropriate ointment or soap and water. Protective ointment, S-461 or S-330 is preferable if no erythema has appeared. If erythema or blisters are present, use only soap and water, except with known lewisite cases, who receive BAL ointment. Washing facilities should be provided if practicable so that a soap and water bath can be given when indicated.

(3) *Area C:* In this area all cases are received. Clean cases are admitted directly; contaminated cases only after passing through A and B. Note exception in the case of area A′B′ below for contaminated emergencies.

(4) *Area D:* Special treatments are given in this area, including facilities for soaping and washing off with water.

(5) *Area A′B′:* Here medical personnel are detailed to attend casualties requiring immediate medical and surgical aid which is more urgent than personal decontamination. Once emergency service

is rendered the casualty, personal decontamination is completed here. Medical personnel wear gas masks, protective aprons, and apply protective ointment, S-461 or S-330 to their hands and carry out personal decontamination before returning to the clean medical facility. It may be an extemporized facility or a room designated for the purpose. It cannot be used later for clean cases, but can be reserved for similar emergencies. It must be recognized as a contaminated area and respected accordingly.

(6) *Area E:* The casualties are held in this area to await evacuation.

(a) A most important need is efficient sorting of casualties in Area A by an officer or a non-commissioned officer.

(b) The personnel employed in Area A, in addition to hospital corpsmen assigned for sorting, should be the litter bearers who bring in the casualties.

(c) In Area B the undressers will be hospital corpsmen detailed for the special activity required in this area.

E. Reception of Contaminated Casualties at Rear Zone Installations

(1) Reception and handling of chemical casualties at fixed installations in zones well to the rear require certain modifications of the above plan. Two types of contaminated casualties must be expected: Those incurred in the vicinity of the installation and probably grossly contaminated, such as would occur with a high explosive bombing followed by chemical attack; and those incurred in a forward area some time earlier, and evacuated after personal decontamination to the hospital for treatment. The latter are clean cases and present no problem as to reception. The former present a considerable problem.

(2) The present problem with regard to reception and handling of chemical casualties at fixed medical establishments is one of *decentralization*, as opposed to the former ideas of a single decontamination center for all chemical casualties. *Any plan which permits a line of individuals to await decontamination at a centralized point will result in increasing the degree of injury due to this delay.*

(3) It is essential that contaminated clothing be removed at the earliest opportunity and *that there be available multiple decentralized reception points*, i.e., "dirty" areas A and B, and "clean" area C, all blister gas contaminated casualties being segregated from clean casualties, until the former have been properly decontaminated.

(4) Blister gas contaminated wounded can be taken from the place of sorting to ward entrances, just forward of which (Area A or Area A-B) clothing will be removed by litter bearers and placed in bins, sacks or piles to await periodical collection by decontamination squad personnel. Here also valuables will be properly cared for until decontamination can be carried out. If no special entrance facility has been

provided, the casualty will be contaminated just forward of the entrances to the ward, as in Area A-B, and changed to a new litter and blanket, then passed just inside the entrance as in Area C. At times, in very cold weather, it may be necessary to carry out Area B activities just inside the ward entrance. It may be possible to plan for reception of such contaminated casualties via an entrance or facility which is set aside to provide for the procedures normally carried out in Area B of basic plan.

(5) At times it may appear to be necessary for certain emergency cases to by-pass all of these various points and proceed directly to an operating room. *If this is done, it must be remembered that the room and equipment will become contaminated and this must be taken care of before subsequent casualties may be cared for.* From the military standpoint it is undesirable, because of interior contamination, to lose the use of such an important operating facility. It is necessary to have an alternative plan where the operating team can go to an improvised operating room to care for such emergencies (Area A′B′). All personnel handling emergency contaminated casualties must wear gas masks and protective aprons, and should observe personal decontamination with regard to their hands on completion of the emergency operation. Following removal of mask, protective apron and completion of personal decontamination, personnel who have been attending contaminated casualties in such an emergency operating facility may safely return to a clean operating room. The U. S. Navy individual protective cover serves well as a protective apron.

(6) In all medical establishments therefore, there should be set up a special facility parelleling the operating room, in which contaminated surgical emergencies can be handled. The general principle to be observed is maintaining the normal medical or surgical facilities as free from contamination as possible, employing an alternative facility for the care of such a contaminated emergency casualty.

(7) The basic plan and principles to follow are those outlined for Area A, B, C, D, and E. A diversity of plans, employing these principles, is possible providing adequate means are available for handling such contaminated casualties.

(8) The planning for the choking gas casualties presents mainly the problem of providing large amounts of oxygen and personnel in adequate numbers with the proper training to administer the oxygen to such cases.

NAVY AND MEDICAL SUPPLY DEPOT ITEMS FOR SELF-AID AND DEFINITIVE TREATMENT OF CHEMICAL WARFARE CASUALTIES

Stock No.	Item	Unit	Quantity
	S2–1058 Kit, First-aid (Gas Casualties): (contents)		
1-140	AMYL NITRITE, 5 minim pearl	12 in box	1
S1-3355	OINTMENT, ANESTHETIC	1-oz. tube	1
S1-3361	OINTMENT, BAL	½-oz. tube	1
S1-3365	OINTMENT, BUTYN OPHTHALMIC, 2%.	1-dr. tube	2
S1-3375	OINTMENT, PROTECTIVE, S-330	3-oz. tube	2
S2-845	COTTON PADS, 1 in. by 2 in	50 in pkg	1
S2-1373	PAD, Copper Sulfate impregnated, 3 in. by 3 in.	3 in pkg	4
	14-055 Field Medical No. 10 CASE, Treatment Chemical Casualties		
	Packing: Case 1 and 2 hard fibre suitcases in canvas carrying case. Case 3 and 4 in canvas carrying case, 26 by 13 by 9 in. Weight: Case No. 1, 38 lb.; case No. 2, 40 lb.; case No. 3, 50 lb. case No. 4, 39 lb. Total measurements: 7.6 cu.ft.		
	Case No. 1		
1-140	AMYL NITRITE, 5 minim pearl	12 in box	8
1-245	CHLOROFORM (for anesthesia)	¼-lb. bot	2
1-495	MORPHINE TARTRATE, 0.032 Gram, 1½ cc. tube with sterile needle.	Syrette	5
1-725	SOAP, hard (Castile)	1-lb. pkg	1
1-745	SODIUM BICARBONATE	1-lb. ctn	1
1-995	CODEINE SULFATE, 0.0162 Gram	100 bot	1
2-135	BATH, eye	One	6
2-350	COTTON, absorbent, compressed	1-oz. pkg	6
2-435	GAUZE, plain, compressed	1-oz. pkg	25
2-580	NEEDLE, hypodermic, length 2 in., 18-gage	Doz	1
2-1240	SYRINGE, intramuscular, glass, 10 cc	One	1
3-766	SHEARS, bandage, angular, 5½ in. (Lyster)	One	1
3-865	SUITCASE, hard fiber, 24 by 12 by 8 in	One	1
4-110	BOTTLE, 8 fl. oz	Doz	1/12
4-745	MEDICINE DROPPER	Doz	½
6-235	SPOON, table	One	1

Stock No.	Item	Unit	Quantity
13-025	BASIN, hand, rubber, collapsible	One	1
13-185	STIRRER, wood, ½ by 12 in	One	1
13-210	TIN, ½ gal. capacity	One	1
14-280	CASE, canvas, carrying	One	1
14-500	SPOON, tea	One	1
S1-110	BAL IN OIL, 10%, 5 cc. ampul	10 in box	1
S1-3355	OINTMENT, ANESTHETIC	1-oz. tube	5
S1-3361	OINTMENT, BAL	Tube	50
S1-3362	OINTMENT, BORIC ACID	4-oz. tube	10
S1-3365	OINTMENT, BUTYN, ophthalmic 2%	1-dr. tube	12
S1-3375	OINTMENT, PROTECTIVE (S-330)	3-oz. tube	50
S1-3381	OINTMENT, SULFATHIZOLE, OPHTHALMIC 5%.	⅛-oz. tube	12
S1-3785	SOLUTION, ANESTHETIC	1-oz. bot	1
S2-1373	PAD, copper sulfate, impregnated 3 in. by 3 in.	3 in. pkg	4
S15-102	CHEMICAL WARFARE: Treatment of Casualties From Chemical Warfare Agents (NavMed 220—Revised).	One	1
	Case No. 2		
1-140	AMYL NITRITE, 5 minim pearl	12 in box	7
1-245	CHLOROFORM (for anesthesia)	¼-lb. bot	2
1-495	MORPHINE TARTRATE, 0.032 Gram—1½ cc. tube with sterile needle.	Syrette	5
1-725	SOAP HARD (Castile)	1-lb. pkg	1
1-745	SODIUM BICARBONATE	1-lb. ctn	1
1-980	ACID, ACETYLASALICYLIC, 0.324 Gram.	1,000 bot	1
1-995	CODEINE SULFATE, 0.0162 Gram	100 bot	1
2-135	BATH, eye	One	6
2-350	COTTON, absorbent, compressed	1-oz. pkg	6
2-435	GAUZE, plain, compressed	1-oz. pkg	25
3-766	SHEARS, bandage, angular, 5½ in	One	1
3-865	SUITCASE, hard fiber, 24 by 12 by 8 in	One	1
4-730	MEASURE, glass, graduated, 500 cc	One	1
4-745	MEDICINE DROPPER	Doz	½
13-025	BASIN, hand, rubber, collapsible	One	1
13-185	STIRRER, wood, ½ by 12 in	One	1
13-210	TIN, ½ gal. capacity	One	1
14-280	CASE, Canvas, carrying	One	1
14-500	SPOON, tea	One	1
S1-3355	OINTMENT, ANESTHETIC	1-oz. tube	5
S1-3361	OINTMENT, BAL	Tube	50
S1-3362	OINTMENT, BORIC ACID	4-oz. tube	10
S1-3365	OINTMENT, BUTYN, ophthalmic 2%	1-dr. tube	12
S1-3375	OINTMENT, PROTECTIVE, (S-330)	3-oz. tube	50
S1-3381	OINTMENT, SULFATHIAZOLE, OPHTHALMIC 5%.	⅛-oz. tube	12

Stock No.	Item	Unit	Quantity
S1-3565	POWDER, BLEACHING, HIGH TEST HYPO.	3¾-lb. cont	1
S1-3785	SOLUTION, ANESTHETIC	1-oz. bot	1
S2-1373	PAD, Copper Sulfate, impregnated, 3 in. by 3 in.	3 in pkg	4
S15-102	CHEMICAL WARFARE: Treatment of Casualties From Chemical Warfare Agents (NavMed 220—Revised).	One	1
	Case No. 3		
13-025	BASIN, hand, rubber, collapsible	One	2
13-105	GLOVES, acid, rubber	Pair	8
14-280	CASE, canvas, carrying	One	1
S13-010	APRON, impermeable, surgeon's	One	2
S13-500	OVERSHOES, rubber	Pair	8
S15-102	CHEMICAL WARFARE: Treatment of Casualties From Chemical Warfare Agents (NavMed 220—Revised).	One	1
	Case No. 4		
14-280	CASE, canvas, carrying	One	1
S13-700	SUIT, gas-resistant, with gloves and socks	Set	8

ADDITIONAL ITEMS NOT IN UNIT

Stock No.	Item	Unit
1-150	ATROPINE SULPHATE	15-grain vial.
1-170	BISMUTH SUBCARBONATE	1-lb. ctn.
1-175	BISMUTH SUBNITRATE	¼ lb. bot.
S1-2601	FLUORESCEIN SODIUM	10 Gram bot.
S1-1130	PENICILLIN SODIUM, Crystalline 100,000 Oxford Units.	Ampule.
S1-3530	PLASMA, Normal Human Dried	250 cc.
S1-3531	PLASMA, Normal Human Dried	500 cc.
S1-4315	SODIUM BICARBONATE, 0.648 Gram	100 bot.
S1-4316	SODIUM BICARBONATE, 0.648 Gram	1,000 bot.
S1-3808	SULFADIAZINE, 1 Gram Tablets	24 pkg.
S1-4341	SULFANILAMIDE, 0.324 Gram Tablets	100 bot.
S1-3790	SOLUTION DEXTROSE, 5% normal	1,000 cc.
S1-3795	SOLUTION, Normal Saline	1,000 cc.
S1-2092	TETANUS TOXOID, Alum Precipitated	10 cc. vial.
S1-4790	ZEPHIRAN CHLORIDE, aqueous (concentrate)	4-oz. bot.

SYLLABUS OF INSTRUCTION AND TRAINING IN CHEMICAL WARFARE DEFENSE FOR ALL MEDICAL PERSONNEL

(10-Hour Course)

A. Basic Gas Defense Instruction and Training

(1) Five-hour, 10-hour, or 24-hour course depending upon the local command. The chemical warfare officer of each unit or sub unit is responsible for this training which includes all naval personnel. (Ref: Chapter 12, Defensive Chemical Warfare Manual, FTP 222, United States Fleet)

B. Medical Gas Defense Instruction and Training

(1) General:

FIRST HOUR

(a) Introduction to Problem.
(b) War gases, Physiological Classification of:
    1. Blister Gases.
    2. Choking Gases.
    3. Blood and Nerve Poisons.
    4. Vomiting Gases.
    5. Tear Gases.
(c) Screening Smokes.
(d) Incendiaries.

(2) Effects of chemical warfare agents on the body; personal decontamination first aid and treatment relating to the eyes, the skin, the respiratory tract and systemically.

SECOND HOUR—BLISTER GASES

(a) Mustard gas (H) and Guide for Disposition of Personnel.
(b) Nitrogen mustard gas (HN).

THIRD HOUR—BLISTER GASES (continued)

(a) Lewisite (L), Ethyldichlorarsine (ED), Phenyldichlorarsine (PD).
(b) Mixed blister gases (H & L, HN & L, etc.)

FOURTH HOUR—CHOKING GASES

(a) Phosgene (CG), Chlorpicrin (PS), Chlorine (CL).

FIFTH HOUR—BLOOD AND NERVE-POISONS AND TEAR GASES

(a) Hydrocyanic Acid (AC), Cyanogen Chloride (CK), Arsine (SA).
(b) Chloracetophenone (CN), Chloraceptophenone Solution (CNS), Chloracetophenone Training Solution (CNB), Brombenzylcyanide (BBC).

SIXTH HOUR—VOMITING GASES AND SCREENING SMOKES

(a) Adamsite (DM), Diphenylchlorarsine (DA) Diphenylcyanarsine (DC).
(b) Hexachlorethane Mixture (HC), Sulfur Trioxide (FS), Titanium Tetrachloride (FM), White Phosphorus (WP).
(c) Incidental Gases (CO, H_2S, NO and NH_3)

SEVENTH HOUR

(a) Incendiaries: Thermite (TH), Magnesium (Mg), Oil Incendiaries (IM) (NP).

(b) Treatment of Burns: White Phosphorus (WP) and Incendiaries (TH), (IM), (NP).

(3) *Special medical instruction and training:*

EIGHTH HOUR—MANAGEMENT AND TRANSPORT OF CHEMICAL WARFARE CASUALTIES IN NAVAL AND MARINE CORPS FORCES

(a) General.

(b) Evacuation of Casualties Seaward from Shore.

(c) Evacuation of Casualties Ashore.

NINTH HOUR

(a) Resuscitation and oxygen therapy as applied to gas casualties.

(b) Contamination of food and water:

1. General problems.
2. Kit, water testing and screening.

(c) Gas defense bill: Application of bill to medical organization.

(4) *Summary of course:*

TENTH HOUR

(a) Review.

(b) Quiz.

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CHEMICAL WARFARE REFERENCE CHART

Tactical Class	Physiological Class	Symbol	Name	Odor	Color and State	Persistence	Effect on Body	Protection	Self-Aid Must be Immediate
CASUALTY GASES	Blister Gases	H	Mustard	Garlic Horse-radish	Dark-oily liquid Colorless gas	1 day to all Winter	No immediate symptoms, 3 to 36 hrs. later irritates eyes, skin, nose, lungs; Worse in Tropics.	Gas masks Eye shields Protective clothing Protective covers	*Skin*—Blot, not rub, off liquid. Rub in ointment S–461 or S–330. Do not use in eyes *or on reddened skin*. *Clothes*—Remove clothing contaminated and discard. Avoid fumes. Treat underlying skin. *Eyes*—See Mixed.
		HN	Nitrogen Mustards	Faint; Fishy	Dark-oily liquid Colorless gas	2 hours to days	Irritation of eyes appear more quickly than H. (20 minutes).		
		L	Lewisite	Geraniums	Dark-oily liquid Colorless gas	1 day to 1 week	Immediate stinging pain of eyes and skin. Irritates nose, throat and lungs. Worse in Tropics.		*Skin*—Blot, not rub, off liquid. Rub in BAL ointment. *Clothes*—See H. *Eyes*—See Mixed.
		ED	Ethyldichlorarsine	Biting and Stinging	Colorless or brown liquid colorless gas	1 to 12 hours			
		PD	Phenyldichlorarsine	Shoe polish	Clear, viscid liquid	Hours to days			
		Mixed	H- and L, -ED, -PD; HN and -L, -ED, -PD.	Combination of H and L, ED, PD	Combination of H and L, ED, PD.		Combination of H and L, ED, PD.		*Skin*—Blot, not rub, off liquid. Treat with ointment S–461 or S–330 for H; remove, use BAL ointment for L. Wash with soap and water. *Eyes*—All contamination of the eyes by any liquid blister gas are decontaminated by *one standard procedure*: BAL ointment into the eye or lower lid, massage for 1 min., wash out with water for 30 sec. to 2 minutes.
	Choking Gases	CG	Phosgene	Musty hay Green corn	Colorless gas	1 to 10 minutes	Coughing, choking, difficulty in breathing. Fluid in lungs.	Gas masks	If breathing becomes difficult keep quiet and comfortably warm until given medical attention.
		PS	Chlorpicrin	Flypaper Licorice	Yellow oily liquid Colorless gas	1 hour to 1 week	Irritates eyes. Same as CG.	Gas masks	Rest and comfortably warm. Wash eyes, nose and throat for irritation.
		CL	Chlorine	Chloride of lime	Greenish-yellow gas	10 min. to 1 hour	Same as PS.	Gas masks	Same as PS.
	Blood and Nerve Poisons	AC	Hydrocyanic Acid	Bitter almond	Colorless liquid or gas	1 to 10 minutes	Dizziness, headache, coma.	Gas masks	Hold breath 'till masked. Whiffs of amyl nitrite. If not breathing—artificial respiration.
		CK	Cyanogen Chloride	Biting	Colorless liquid or gas	1 to 10 minutes	Irritates eyes, nose, throat. Also as AG.		
HARASSING GASES	Tear Gases	CN	Chloracetophenone	Apple blossoms	Cloud of particles, droplets	10 min. to weeks	Irritates eyes. Heavy concentration irritates nose, throat, and lungs. Also burns and blisters the skin in warm climates.	Gas masks	Wash out eyes with water and wash skin with soap and water. Face upwind. Additional self-aid usually not necessary.
		CNS	Chloracetophenone Solution	Fly paper	Cloud of particles, droplets	1 hour to 1 week			
		CNB	Chloracetophenone Training Solution	Sweetish Benzine	Cloud of particles, droplets	Not determined			
		BBC	Brombenzyl Cyanide	Sour fruit	Colorless liquid or gas	Days to weeks			
	Vomiting Gases	DM	Adamsite	Coal smoke	Yellow cloud	10 minutes	Irritates eyes, nose, and throat, vomiting, headache.	Gas masks	Sniff chloroform. Keep masked. Lift mask only when actually vomiting. Additional self-aid usually not necessary.
		DA	Diphenylchlorarsine	Shoe polish	White or gray cloud	5 to 10 minutes			
		DC	Diphenylcyanarsine	Garlic Bitter almond	White cloud	5 to 10 minutes			
SCREENING SMOKES		HC	Hexachlorethane Mixture	Sharp; Stinging	White to gray smoke	While burning	Heavy concentration irritates eyes, nose and throat—may cause difficulty in breathing in high concentrations. FS and FM liquid burns skin.	Gas masks for heavy concentrations.	If breathing becomes difficult keep quiet and comfortable and comparatively warm until given medical attention. Wash out eyes if irritating. Wash skin burns with water.
		FS	Sulfur Trioxide	Sharp; Stinging	Dense white smoke	5 to 10 minutes			
		FM	Titanium Tetrachloride	Sharp; Stinging	White smoke	10 minutes			
		WP	White Phosphorus	None or Burning matches	Burns to white smoke in air	10 minutes	Burns skin.	Avoid burning particles	Douse burn with canteen water. Apply copper sulfate pad wet with water. Remove particle. Discard pad. Do not use grease or salve.
INCENDIARIES		TH	Thermite Magnesium Bomb	None	White hot metal Burns with white light		Heat, burns.	Avoid burning particles.	Cool burning material and remove. Treat as any burn.
		IM NP	Thickened Gasoline	Burning oil	Yellow jelly Black smoky flame				